WATERSHED WORK PLAN

WAILUKU-ALENAIO WATERSHED

HAWAII COUNTY, HAWAII

March, 1976

Soil Conservation Service

Forest Service

ADDENDUM

September 1975

WATERSHED WORK PLAN
Wailuku-Alenaio Watershed

County of Hawaii
Hawaii

CONTENTS

INTRODUCTION

This addendum is based on procedures established for application of the Water Resources Council's Principles and Standards to implementation studies in process.

The Wailuku-Alenaio Watershed Work Plan was developed using 1975 installation costs, a 6-1/8 percent discount rate, and normalized prices in the evaluation of the project structural measures.

Part 1 of this addendum shows the effect of evaluating the structural measures using current installation costs and the current discount rate.

Part 2 of the addendum displays the effects of the selected plan as evaluated for each of the separate accounts--national economic development, environmental quality, regional development, and social well-being. Values for costs, prices, and rates are those of the work plan.

Part 3 of the addendum displays an abbreviated alternative plan developed to emphasize environmental quality. Bases for costs, prices, and rates are those of the work plan.

DISCOUNT RATE COMPARISON

The work plan shows an evaluation of the project structural measures using 1975 installation costs and a discount rate of 6-1/8 percent. No further comparison is applicable.

SELECTED ALTERNATIVE
NATIONAL ECONOMIC DEVELOPMENT ACCOUNT
Wailuku-Alenaio Watershed, Hawaii

Components	Measures of Effects 1/ ----- Dollars -----
Beneficial effects:	
A. The value to users of increased outputs of goods and services	
1. Flood prevention	292,500
2. Utilization of unemployed and underemployed labor resources.	
Project construction and OM&R	18,800
Total beneficial effects	311,300

Components	Measures of Effects 1/ ----- Dollars -----
Adverse effects:	
A. The value of resources required for a plan	
1. Debris basins and floodwater diversions	
Project installation	99,440
Project administration	17,170
OM&R	17,140
Total adverse effects	133,750
Net beneficial effects	177,550

1/ Average annual

March 1976

SELECTED ALTERNATIVE
ENVIRONMENTAL QUALITY ACCOUNT
Wailuku-Alenaio Watershed, Hawaii

Components	Measures of effects	Components	Measures of effects
Beneficial and adverse effects:			
A. Areas of natural beauty	1. Reduction of floodwater, erosion, and sediment damage by 99 percent on 970 acres. 2. Approximately 3,500 feet of natural stream channel in the Chong's Bridge area will be modified. 3. Land treatment measures will maintain the present generally favorable condition of the forest. 4. There will be a reduction of sediment pollution to the Wailuku-Alenaio Stream, and Hilo Bay.	D. Irreversible or irretrievable commitment	1. Project installation will eliminate agricultural and forestry production on 12.2 acres of land that will be occupied by the structures.
B. Quality consideration of water, land, and air resources	1. There will be a reduction of erosion in the watershed, and sediment yield from the watershed will be reduced by an estimated 26 percent. 2. Less pollution to Hilo Bay from sediment and nutrients will result in reduced degradation of coastal waters. 3. Air and water pollution will be increased temporarily during the project construction period.		
C. Biological resources and selected ecosystems	1. Brush and grass-type wildlife habitat along the 3,500 feet of channel work near Chong's Bridge will be lost or altered. 2. Land treatment measures on forest lands will protect the ecosystems of natural flora and fauna.		

SELECTED ALTERNATIVE
REGIONAL DEVELOPMENT ACCOUNT
Wailuku-Alenaio Watershed, Hawaii

Components	Measures of Effects 1/ State of Hawaii	Rest of Nation
	----- Dollars -----	
Income:		
Beneficial effects:		
A. The value of increased output of goods and services to users residing in the region.		
1. Flood prevention	292,500	--
2. Utilization of regional unemployed and underemployed resources	18,800	--
B. The value of output to users residing in the region from external economies.		
1. Induced by and stemming from effects	30,900	--
Total beneficial effects	342,200	--

Components	Measures of Effects 1/ State of Hawaii	Rest of Nation
	----- Dollars -----	
Income:		
Adverse effects:		
A. The value of resources contributed from within the region to achieve the outputs.		
1. Debris basins and floodwater diversions		
Project installation	81,690	17,750
Project administration	13,620	3,550
OM&R	17,140	--
Total adverse effects	112,450	21,300
Net beneficial effects	229,750	-21,300

1/ Average Annual

SELECTED ALTERNATIVE
REGIONAL DEVELOPMENT ACCOUNT (Cont'd)
Wailuku-Alenaio Watershed, Hawaii

Components	Measures of Effects 1/ State of Hawaii	Rest of Nation
Employment:		
Beneficial effects:		
A. Increase in number and types of jobs		
1. Employment for project construction	22.8 semi-skilled jobs for one year	--
2. Employment for project OM&R	2.8 permanent semi-skilled jobs	--
3. Employment in service and trade activities induced by and stemming from project operation	13.6 permanent semi-skilled jobs	--
Total beneficial effects	22.8 semi-skilled jobs for one year 16.4 permanent semi-skilled jobs.	

Components	Measures of Effects 1/ State of Hawaii	Rest of Nation
Income:		
Adverse effects:		
A. Decrease in number and types of jobs	0	0
Total adverse effects	0	0
Net beneficial effects	22.8 semi-skilled jobs for one year 16.4 permanent semi-skilled jobs	

March 1976

1/ Average Annual

SELECTED ALTERNATIVE
REGIONAL DEVELOPMENT ACCOUNT (Cont'd)
Wailuku-Alenaio Watershed, Hawaii

Components	Measure of effects	
	State of Hawaii	Rest of Nation
Regional Economic Base and Stability		
Beneficial effects:	This project will reduce flood-water, sediment and erosion damages on 970 acres. Protection will be provided to 560 residents, 136 homes, and 10 diversified agricultural operations. Flood protection and sediment yield reduction are important elements in maintaining the economic base and stability of the area.	

SELECTED ALTERNATIVE
SOCIAL WELL-BEING ACCOUNT
Wailuku-Alenaio Watershed, Hawaii

Components	Measures of Effects
Beneficial and adverse effects:	
A. Real Income Distribution	1. The project will create 22.8 man-years of semi-skilled employment for one year.
	2. The project will create regional[1/] income benefit distribution of $292,500 flood damage reduction benefits by income class as follows:

Income Class - -Dollars- -	Percentage of Adjusted Gross Income in Class	Percentage Benefits in Class
Less than 3,000	-0-	-0-
3,000 - 10,000	65	60
More than 10,000	35	40

3. Local cost to be borne by region totals $112,450 with distribution by income class as follows:

Income Class - -Dollars- -	Percentage of Adjusted Gross Income in Class	Percentage Contributions in Class
Less than 3,000	-0-	-0-
3,000 - 10,000	65	60
More than 10,000	35	40

1/ The realization of these flood damage reduction benefits is considered to occur in the 970-acre flood plain. Secondary benefits ($30,900) will occur in the immediate area.

March 1976

SELECTED ALTERNATIVE
SOCIAL WELL-BEING ACCOUNT
Wailuku-Alenaio Watershed, Hawaii

Components	Measures of Effects
B. Life, health, and safety	1. The structural works will provide a 1 percent level of flood protection to 560 residents in the 970-acre flood plain. The area contains 136 homes and 10 diversified agricultural operations. Future threats of loss of life and displacements during major floods will be reduced.

March 1976

ENVIRONMENTAL QUALITY ALTERNATIVE
Wailuku-Alenaio Watershed, Hawaii

Objectives	Watershed Problems	Component Needs	Opportunities	Plan Elements	Environmental Effects
Maintain and Enhance Environmental Quality	Floodwater damage to agricultural lands and residential and commercial developments. Erosion and sediment damage to cropland. Inadequate shoreline parks. Excess wild sheep and goat populations. Ohia die-off (woodland species). Unfavorable visual aspects of the watershed. Damage to native forest ecosystems. Sediment pollution of the Wailuku River, Alenaio Stream, and Hilo Bay. Sediment damage to residential land. Ponding of water on the flood plain. Inadequate cover on pastureland.	Reduce floodwater damage to the 1,604-acre flood plain which includes the city of Hilo. Reduce potential for damage to future flood plain development. Reduce deposition of sediment on the flood plain and in Hilo Bay. Reduce erosion on cropland. Improve and expand shoreline park. Research to determine cause of Ohia die-off. Game management practices to control sheep and goat populations. Stabilize critical erosion areas (barren areas). Control aggressive exotic vegetation, insect pests, and forest disease. Improve cover on pastureland.	Floodwater retarding structure on Alenaio Stream. Floodwater diversions and channel work. Accelerate land treatment program. Open hunting season for sheep and goats. Secure government grant to study Ohia die-off. Forest management. Land use controls; Flood proofing; Building codes. Initiate study to determine what can be done to improve the shoreline park.	One floodwater retarding structure with 2.1 miles of diversion and .66 mile of channel work. Conservation land treatment on 3,880 acres of cropland, 33,850 acres of pastureland, 1,770 acres of urban and industrial land, and 77,500 acres of forest land. Land use control on 120 acres through flood easements and building codes. Accelerate program to protect and improve forested areas. Estimated installation costs $17,765,000.	AREAS OF NATURAL BEAUTY 1. Channel work will affect the existing natural condition of .66 mile of gulch. 2. Construction of the floodwater retarding structure will create a structural disruption to the natural environment. 3. Prevention of flood damage and sedimentation will allow visual improvements of 1,604 acres. 4. Land use control will encourage open space. 5. Eliminate the critical eroding areas (25 acres) by application of conservation land treatment. QUALITY CONSIDERATION OF WATER, LAND, AND AIR RESOURCES 1. Reduce sediment yield to Alenaio Stream, Wailuku River, and Hilo Bay. 2. Reduce surface ponding of water in the 1,604-acre flood plain. 3. Improve vegetative cover of pastureland. 4. Improve land based resources by application of conservation land treatment. 5. Air and water pollution will be increased slightly during the installation of structural measures. BIOLOGICAL RESOURCES AND SELECTED ECOLOGICAL SYSTEMS 1. Maintain marine life habitat. 2. Improve native forest ecosystems. IRREVERSIBLE OR IRRETRIEVABLE COMMITMENTS 1. Installation of the structural measures will result in the loss of 2.0 acres of sugarcane land, 3.1 acres of pastureland, 6.1 acres of forest land, and 71 acres of brushland. About 170 acres of brushland will be temporarily inundated.

March 1976

WATERSHED WORK PLAN AGREEMENT

between the

Mauna Kea Soil and Water Conservation District

Waiakea Soil and Water Conservation District

County of Hawaii

(hereinafter referred to as the Sponsoring Local Organization)

State of Hawaii

and the

Soil Conservation Service
United States Department of Agriculture
(hereinafter referred to as the Service)

Whereas, application has heretofore been made to the Secretary of Agriculture by the Sponsoring Local Organization for assistance in preparing a plan for works of improvement for the Wailuku-Alenaio Watershed, State of Hawaii, under the authority of the Watershed Protection and Flood Prevention Act (P.L. 566, 83d Congress; 68 Stat. 666), as amended; and

Whereas, the responsibility for administration of the Watershed Protection and Flood Prevention Act, as amended, has been assigned by the Secretary of Agriculture to the Service; and

Whereas, there has been developed through the cooperative efforts of the Sponsoring Local Organization and the Service a mutually satisfactory plan for works of improvement for the Wailuku-Alenaio Watershed, State of Hawaii, hereinafter referred to as the watershed work plan, which plan is annexed to and made a part of this agreement;

Now, therefore, in view of the foregoing considerations, the Sponsoring Local Organization and the Secretary of Agriculture, through the Service, hereby agree on the watershed work plan, and further agree that the works of improvement as set forth in said plan can be installed in about 10 years.

It is mutually agreed that in installing and operating and maintaining the works of improvement substantially in accordance with the terms, conditions, and stipulations provided for in the watershed work plan:

1. The Sponsoring Local Organization will acquire, with other than PL-566 funds, such land rights as will be needed in connection with the works of improvement. (Estimated cost $289,000.)

2. The Sponsoring Local Organization assures that comparable replacement dwellings will be available for individuals and persons displaced from dwellings, and will provide relocation assistance advisory services and relocation assistance, make the relocation payments to displaced persons, and otherwise comply with the real property acquisition policies contained in the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (Public Law 91-646, 84 Stat. 1894) effective as of January 2, 1971, and the Regulations issued by the Secretary of Agriculture pursuant thereto. The costs of relocation payments will be shared by the Sponsoring Local Organization and the Service as follows:

	Sponsoring Local Organization (percent)	Service (percent)	Estimated 1/ Relocation Payment Costs (dollars)
Relocation Payments	45.7	54.3	0

1/ Investigation has disclosed that under present conditions the project measures will not result in the displacement of any person, business or farm operation. However, if relocations become necessary, relocation payments will be cost-shared in accordance with the percentages shown above.

3. The Sponsoring Local Organization will acquire or provide assurance that landowners or water users have acquired such water rights pursuant to state law as may be needed in the installation and operation of the works of improvement.

4. The percentages of construction costs of structural measures to be paid by the Sponsoring Local Organization and by the Service are as follows:

Works of Improvement	Sponsoring Local Organization (Percent)	Service (Percent)	Estimated Construction Cost (Dollars)
Stream Channel Works and Floodwater Diversion Channels	0	100	1,108,500

5. The percentages of the engineering costs to be borne by the Sponsoring Local Organization and the Service are as follows:

Works of Improvement	Sponsoring Local Organization (Percent)	Service (Percent)	Estimated Engineering Costs (Dollars)
Stream Channel Works and Floodwater Diversion Channels	0	100	221,750

6. The Sponsoring Local Organization and the Service will each bear the cost of Project Administration which it incurs, estimated to be $57,800 and $221,750 respectively.

7. The soil and water conservation districts will provide assistance to land owners and operators to assure the installation of the land treatment measures shown in the watershed work plan.

8. The soil and water conservation districts will encourage land owners and operators to operate and maintain the land treatment measures for the protection and improvement of the watershed.

9. The Sponsoring Local Organization will be responsible for the operation and maintenance of the structural works of improvement by actually performing the work or arranging for such work in accordance with agreements to be entered into prior to issuing invitations to bid for construction work.

10. The Sponsoring Local Organization, in cooperation with the Department of Land and Natural Resources, will comply with Chapter 6 of the Hawaii Revised Statutes pertaining to investigating, recording, and salvaging archeological, prehistoric, and historic sites and remains in the watershed area.

11. The costs shown in this agreement represent preliminary estimates. In finally determining the costs to be borne by the parties hereto, the actual costs incurred in the installation of works of improvement will be used.

12. This agreement is not a fund obligating document. Financial and other assistance to be furnished by the Service in carrying out the watershed work plan is contingent on the availability of appropriations for this purpose.

    A separate agreement will be entered into between the Service and the Sponsoring Local Organization before either party initiates work involving funds of the other party. Such agreement will set forth in detail the financial and working arrangements and other conditions that are applicable to the specific works of improvement.

13. The watershed work plan may be amended or revised, and this agreement may be modified or terminated only by mutual agreement of the parties hereto except for cause. The Service may terminate financial and other assistance in whole, or in part, at any time whenever it is determined that the Sponsoring Local Organization has failed to comply with the conditions of this agreement. The Service shall promptly notify the Sponsoring Local Organization in writing of the determination and the reasons for the termination, together with the effective date. Payments made to the Sponsoring Local Organization or recoveries by the Service under projects terminated for cause shall be in accord with the legal rights and liabilities of the parties.

14. No member of or delegate to Congress, or resident commissioner, shall be admitted to any share or part of this agreement, or to any benefit that may arise therefrom; but this provision shall not be construed to extend to this agreement if made with a corporation for its general benefit.

15. The program conducted will be in compliance with all requirements respecting nondiscrimination as contained in the Civil Rights Act of 1964, as amended, and the regulations of the Secretary of Agriculture (7 C.F.R. 15.1-15.12), which provide that no person in the United States shall, on the ground of race, color, or national origin, be excluded from participation in, be denied the benefits of, or be otherwise subjected to discrimination under any activity receiving federal financial assistance.

16. This agreement will not become effective until the Service has issued a notification of approval and authorizes assistance.

MAUNA KEA SOIL AND WATER CONSERVATION DISTRICT
Local Organization

By James P.D. Thuss Jr.

Title Chairman

P. O. Box 86
Honokaa, HI 96727
Address Zip Code

Date Feb. 13, 1976

The signing of this agreement was authorized by a resolution of the governing body of the Mauna Kea Soil and Water Conservation District adopted at a meeting held on 2/13/76.

Hazel Edwards
Secretary

P. O. Box 86, Honokaa, HI 96727
Address Zip Code

Date Feb. 13, 1976

WAIAKEA SOIL AND WATER CONSERVATION DISTRICT
Local Organization

By Myron M. Akuna

Title Chairman

P. O. Box 1361
Hilo, Hawaii 96720
Address Zip Code

Date February 9, 1976

The signing of this agreement was authorized by a resolution of the governing body of the Waiakea Soil and Water Conservation District adopted at a meeting held on February 9, 1976.

Secretary

P. O. Box 1361, Hilo, Hawaii 96720
Address Zip Code

Date February 9, 1976

COUNTY OF HAWAII
Local Organization

25 Aupuni St.
Hilo, Hawaii 96720
Address Zip Code

By [signature]

Title Mayor

Date Feb. 19, 1976

The signing of this agreement was authorized by a resolution of the governing body of the County of Hawaii adopted at a meeting held on FEB 18 1976.

[signature]
(County Clerk)
OFFICE OF THE COUNTY CLERK
HAWAII COUNTY BUILDING
25 AUPUNI STREET
Address HILO, HAWAII 96720 Zip Code

Date FEB 19 1976

Appropriate and careful consideration has been given to the environmental impact statement prepared for this project and to the environmental aspects thereof.

Soil Conservation Service
United States Department of Agriculture

Approved by:

[signature]
State Conservationist

FEB 24 1976
Date

WATERSHED WORK PLAN

WAILUKU-ALENAIO WATERSHED PROJECT

Hawaii County, Hawaii

Prepared Under the Authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83d Congress, 68 Stat. 666), as amended.

Prepared by:

Mauna Kea Soil & Water Conservation District

Waiakea Soil & Water Conservation District

and

County of Hawaii

With assistance from:

U.S. Department of Agriculture, Soil Conservation Service

U.S. Department of Agriculture, Forest Service

March 1976

TABLE OF CONTENTS

TABLE OF CONTENTS
(Continued)

WATERSHED WORK PLAN

WAILUKU-ALENAIO WATERSHED

County of Hawaii, Hawaii

SUMMARY OF PLAN

The 167,000-acre Wailuku-Alenaio Watershed is on the northeastern side of the island of Hawaii, popularly known as the Big Island. Present land use includes 46.5 percent in woodland, 29.8 percent in barren lava and cinderlands, 20.2 percent in pasture, 2.5 percent in cultivated crops, and 1.0 percent in urban and industrial use.

The watershed work plan was prepared by the Mauna Kea and Waiakea Soil and Water Conservation Districts (SWCD) and the County of Hawaii (the sponsoring local organizations). Technical assistance was provided by the Soil Conservation Service (SCS) and the Forest Service of the U.S. Department of Agriculture.

Primary objectives of the project are to provide effective land treatment; to prevent floodwater, sediment and erosion damage and maintain wildlife habitat in the flood plain; and to reduce sediment pollution of the streams and Hilo Bay.

The principal watershed problems consist of flood damage to agricultural lands, residential areas, and commercial developments; and sediment pollution of Wailuku River, Alenaio Stream, and Hilo Bay.

Ten years will be required to accomplish the plan. The estimated cost is $3,021,200, which includes $1,642,000 of federal funds provided under Public Law 566.

Proposed land treatment measures include conservation practices to reduce flood runoff and sediment production, maintain favorable soil conditions and productivity, and maintain vegetative cover for soil protection.

Land owners and operators will be responsible for installing and maintaining land treatment measures. SCS and the State Division of Forestry will provide technical help through agreement with SWCDs. Installation will cost an estimated $1,122,400, which includes $90,000 of PL-566 funds for accelerated technical assistance to land owners and operators.

Structural measures include 11,270 feet of floodwater diversions, 3,500 feet of stream channel work, and 1,000 feet of rubble masonry wall. The County of Hawaii will be responsible for installing, operating, and

maintaining structural measures, with technical assistance from SCS. Installation will cost an estimated $1,898,800, which includes $1,552,000 of PL-566 funds for construction, engineering services, and project administration.

Estimated average annual benefits attributed to structural measures are $342,200. These consist of $292,500 in damage reduction benefits, $30,900 in secondary benefits, and $18,800 in redevelopment benefits. Estimated average annual costs are $133,750, which includes operation and maintenance costs of $17,140. The benefit-to-cost ratio is 2.6 to 1.

Installation of the structural measures will protect the agricultural areas from the 4 percent chance storm and the urban areas of Kaumana, Chongmanville, and Ainako from the 1 percent chance storm. The installation of the proposed land treatment measures will reduce the sediment yield from the various land uses: cropland, 52 percent; pasture, 18 percent; urban, 38 percent. These reductions will result in less sediment pollution to the Wailuku River, Alenaio Stream and Hilo Bay.

Some of the environmental impacts of the project are: reduction of sediment pollution to Alenaio Stream, Wailuku River, and Hilo Bay; clearing of 6.1 acres of grazed woodland, 3.1 acres of pasture, 2 acres of sugarcane and 1 acre of urban land to enable construction of the project; and the reduction of erosion on crop, pasture and urban lands.

WATERSHED RESOURCES - ENVIRONMENTAL SETTING

Physical Data

The Wailuku-Alenaio Watershed is on the island of Hawaii, the largest (4,037 square miles) and youngest island of the Hawaiian Archipelago. The island comprises the County of Hawaii. Hilo, the county seat and principal urban center, is located in the lower portion of the watershed and is about 200 miles southeast of Honolulu, the state capital.

The Big Island is a "subregion" of the Hawaiian water resource region established by the Water Resources Council to include the whole state. The most serious water problems in the watershed are flooding of agricultural, residential, and commercial areas; erosion and sedimentation affecting agricultural lands; and sediment pollution in Hilo Bay caused by heavy rains.

The 167,000-acre watershed is in the Mauna Kea and Waiakea SWCDs at about latitude 19°40' N. and longitude 155°20' W. It is triangular in shape with Hilo, Mauna Kea, and Mauna Loa volcanoes as boundary points (see Project Map). Two streams outlet into Hilo Bay--the Wailuku River, which drains about 96 percent of the watershed, and Alenaio Stream.

The northern part of the watershed, formed by Mauna Kea, has a well-defined channel system on the middle and lower slopes. Recent lava flows from Mauna Loa have obliterated natural drainageways, causing floodwaters to flow over wide areas.

Large amounts of runoff water enter lava tubes and rock fractures in the area but some return to the surface as springs that flood the developed areas.

Soils

Four soil associations represent the general soil areas in the watershed (Figure 1).

1. Akaka-Honokaa-Kaiwiki consists of deep, moderately well to well-drained, moderately fine-textured soils formed from volcanic ash on the lower slopes of Mauna Kea. Elevation ranges from near sea level to 6,000 feet. Annual rainfall is 100 to 300 inches. These soils produce sugarcane from sea level to 1,700 feet with ohia-koa forest above 1,700 feet. They have low bearing capacity and are not well-suited for roads and buildings. This association comprises about 18 percent of the watershed.

2. Kekake-Keei-Kiloa consists of very shallow well-drained, organic soils over pahoehoe or fragmented aa lava. The soils occur on gently sloping to steep mountain slopes. Elevation ranges from near sea level to 7,000 feet. Annual rainfall ranges from 40 inches to more than 150 inches. Most of the acreage is in ohia forest but the soils are also used for pasture, watershed, and recreation. They have low bearing capacity, but development of roads and buildings is possible because of the shallow depth to rock. This association comprises about 10 percent of the watershed.

3. Hanipoe-Maile-Puu Oo consists of deep, well-drained, medium-textured soils formed from volcanic ash on gently sloping to steep mountain slopes. Elevation ranges from 2,500 to 8,000 feet. Annual rainfall is 30 to 120 inches. Most of the area is forest and natural vegetation. However, the soils are ideal for pasture and, where land is not too steep, vegetable crops. They have low bearing capacity and are not well-suited for roads and buildings. This association comprises about 15 percent of the watershed.

4. The Lava flows consists of nearly barren lava flows and sandy and cindery soils developed from volcanic ash, pumice, and cinders on gently sloping to steep mountain slopes. Elevation ranges from near sea level to 13,000 feet. Annual rainfall is 10 to 250 inches. Most acreage is in forest and is used for wildlife and recreation. Homes and other facilities are potential uses in areas close to utilities. This association comprises about 57 percent of the watershed.

Climate

Hawaii, at the northern edge of the tropics, enjoys a subtropical climate. Hilo's mean temperature is 73.3°F., with an average minimum of 65.5° and an average maximum of 80.0°. Relatively uniform temperatures and day lengths provide a 12-month growing season with only slight growth reduction from October to April.

Annual rainfall averages 140 inches at Hilo, increasing to 300 inches at 3,000 feet (a distance 7 miles inland), then decreases to 50 inches at 6,500 feet and 10 inches near the top of Mauna Kea (13,796 feet). Highest monthly rainfall averages 25 inches in March; the lowest is 12 inches in June. Mauna Loa and Mauna Kea usually are snowcapped in December and January, but this does not affect stream flows in the drainage area. Heavy rainfall is produced by cold-front and "kona," or southerly storms, which usually occur during winter, and tropical storms and hurricanes which might occur between July and December.

Mineral and Ground Water Resources

Literature on Hawaiian geology indicates no known mineral resources in the watershed. However, lava rock in the area is used for construction of walls, fountains, rock gardens, and decorative facings on buildings.

The city of Hilo is supplied with water from both surface and basal ground water sources. During heavy rains when surface sources are subjected to turbidity problems, the system is regulated by the use of basal water supplies. To meet future needs, plans call for expanding both ground and surface sources.

Vegetative Cover and Land Use

The Hawaii Land Use Law, passed by the 1961 Legislature, gives the state power to classify and regulate land for urban, rural, agriculture and conservation uses. Objectives include protection of prime agricultural land and advancement of orderly urban growth. Use of land classified as "conservation," including the Hilo Forest Reserve, is regulated by the State Department of Land and Natural Resources.

Cultivated crops occupy 3,800 acres (2.5 percent) of the watershed. Sugarcane is grown on 3,790 acres extending from the lower boundary of the forest reserve to the urban areas. About 90 acres produce ornamental plants, truck crops, fruits, and flowers.

Pastureland occupies 33,850 acres (20.2 percent) primarily in a belt between 5,000 and 8,000 feet elevation on Mauna Kea. It generally is devoted to beef production although some improved pasture is used for dairy cattle and hog operations.

Woodland, mostly in the state-owned forest reserve, occupies 77,500 acres (46.5 percent). Forest reserve lands, except the mountain slopes grazed by wild sheep, generally are undisturbed and in good hydrologic condition.

About 50,000 acres (29.8 percent) are barren lava and cinderland on the upper slopes of Mauna Loa and Mauna Kea.

Urban and industrial land occupies the remaining 1,770 acres (1.0 percent). (See Figure 2.)

Land Use	Acreage	Percent of Total
Cultivated Crops	3,880	2.5
Pasture		
Improved pasture	3,740	2.2
Grassland	30,110	18.0
Woodland		
Forest Reserve (general use)	10,500	6.2
" " (closed watershed)	45,500	27.8
" " (game reserve)	6,500	3.8
" " (public hunting - Game management area)	5,500	3.2
Outside Reserve - not grazed	4,500	2.6
- grazed	5,000	2.9
Barren Lava & Cinderland	50,000	29.8
Urban & Industrial	1,770	1.0
	167,000	100.0

Major native tree species are ohia (Metrosideros collina) and koa (Acacia koa). Understory trees and shrubs include tree fern (Cibotium spp.), guava (Psidium guajava), melastoma (Melastoma malabathricum), kolea (Myrsine spp.), kopiko (Straussia spp.), manono (Gouldia spp.) and false staghorn fern (Dicranopteris linearis). The higher elevation tree and shrub types include mamani (Sophora chrysophylla), naio (Myoporum sandwicense), and pukeawe (Styphelia tameiameiae). About 200 acres of planted eucalyptus (Eucalyptus robusta) forests are located along the lower boundary of the forest reserve and in isolated stands outside the reserve.

Grasses and herbs in pasture and wildlife lands between 5,000 and 8,000 feet elevation include sweet vernal grass (Anthoxanthum odórantum), yorkshire fog (Holcus lanatus), kikuyugrass (Pennisetum clandestinum), white clover (Trifolium repens), and several species of bromegrass (Bromus spp.). Grasses in lower elevations around the Hilo residential areas include carpetgrass (Axonopus affinis), hilograss (Paspalum conjugatum), wainakugrass (Panicum repens), and foxtail (Setaria spp.).

Surface Water Resources

The major water resource in the watershed is the Wailuku River (see Project Map). It has a well-defined channel with some sections 80 feet deep and 250 feet wide and includes many pools and waterfalls carved out of hard lava rock. The Wailuku River system is made up of many tributaries with the perennial flows beginning at the 5,000- to 6,000-foot elevation.

Maximum peak discharge recorded at the Piihonua gauge is 63,400 cubic feet per second (cfs); minimum recorded is 0.25 cfs. The mean annual discharge at the outlet is 540 cfs. The water temperature measurements at the Piihonua gaging station varies from 17°C to 22°C. No sediment load data is available but, according to the U.S. Geological Survey, the sediment load is very small during base flow. Sewage is discharged into the Wailuku River from Amauulu Camp. The discharge location is about three miles downstream from the Piihonua gaging station. The Department of Health, State of Hawaii, took several water samples at and near the point of discharge during December 1971 and January 1972 to determine water quality. The fecal coliform varies from 390 - 110,000 MPN[1]/100cc at the point of discharge to 240 MPN/100cc a few hundred feet downstream. No overbank flow has been recorded.

South of the Wailuku River, Kaluiiki Branch joins Waipahoehoe Stream above Chong's Bridge. The stream then becomes undefined in the wide flood plain below Chong's Bridge where much of the flow percolates into the ground. As the flow disappears below Chong's Bridge into an underground stream as base flow, part of the flow reappears above Komohana Road where it forms Alenaio Stream. These three streams are ephemeral and will flow for several days after heavy rains. Flow from Alenaio Stream enters Waialama Canal and into Wailoa River which discharges into Hilo Bay.

Under the state water quality standard classification, all streams in the watershed are Class 2, except the Wailuku River tributaries which provide Hilo's water supply are Class 1. Hilo Bay and adjacent coastal water is Class A, except a limited area next to the boat docking facilities in the harbor, which is Class B.

Coastal and fresh water is classified in accordance with the uses to be protected in each class. The definitions for Classes A, B, 1, and 2 water are as follows:

Class A Waters

The uses to be protected in this class of water are recreational, including fishing, swimming, bathing, and other water-contact sports and aesthetic enjoyment.

It is the objective for this class of water that its use for recreational purposes and aesthetic enjoyment not be limited in any way. Such water shall be kept clean of any trash, solid materials, or oils and shall not act as receiving waters for any effluent which has not received the best practicable treatment or control compatible with the standards established for this class.

1/ MPN = Most Probable Number

Class B Waters

The uses to be protected in this class of water are small boat harbors, commercial, shipping and industrial, bait fishing and aesthetic enjoyment.

It is the objective for this class of water that discharges of any pollutant be controlled to the maximum degree possible and that sewage and industrial effluents receive the best practicable treatment or control compatible for the standards established for this class.

The Class B designation shall apply only to a limited area next to boat docking facilities in bays and harbors. The rest of the water area in such bay or harbor shall be Class A unless given some other specific designation in Section 5.

Class 1 Waters

The uses to be protected in this class of water are drinking water supply and food processing.

It is the objective of this class of water that they remain in as nearly the natural state as possible with an absolute minimum of pollution from any source.

Class 2 Waters

The uses to be protected in this class of water are bathing, swimming, recreation, growth, and propagation of fish and other aquatic life and agricultural and industrial water supply.

It is the object for this class of water that its use for recreational purposes, propagation of fish, and other aquatic life and agricultural and industrial water supply not be limited in any way. Such water shall be kept clean of trash, solid materials, or oils and shall not act as receiving water for any effluent which has not received the best practicable treatment compatible with the standards established for this class.

Economic Data

About 155,000 acres (93 percent) of the watershed is owned by the state of Hawaii, including 35,000 acres controlled by the Hawaiian Homes Commission. Most of the state lands fall within the Hilo Forest Reserve. The Hawaiian Homes Commission land is leased for pasture and cropland. Almost half of the watershed cropland is leased to the Mauna Kea Sugar Company.

About 12,000 acres (7 percent) of the watershed is in private ownership of which about 4,000 acres is in the forest reserve. The reserve is zoned as "closed watershed" to provide domestic water for Hilo. The remaining 8,000 acres of private land are located near Hilo. Nine landowners hold parcels ranging from 100 to 2,600 acres. The remainder consists of small ownerships and leases.

There are 336 independent sugarcane operators, 52 livestock operators, and 10 truck crop and flower growers. Most of the cane in the watershed is grown north of Wailuku River, where about 3 percent of the state's raw sugar is produced. About 730 acres of the sugarcane land are in private, small ownerships, 1,887 acres owned by Mauna Kea Sugar Company, and 1,173 acres owned by the state. The state-owned sugarcane lands are leased by Mauna Kea Sugar Company who, in turn, subleases these lands to independent growers in small increments of 10 to 15 acres. The present lease and sublease agreements are effective to 1991, after which another agreement will be negotiated.

The growers plant and care for the cane until it is ready for harvest. The sugar company harvests, hauls, and mills the cane charging growers for the services. Cane yields range from 6 to 10 tons an acre depending on cloud cover, severity of drought, flood, or erosion during the 2-year maturity period. Factors such as the small acreages and leasing arrangements decrease the profit potential available to small farmers. Uncertain conditions and low economic returns have forced many to seek additional employment in agricultural, construction, and tourist industries. Therefore, the job of maintaining small farms falls to family members after work or school.

Timber production is not a major enterprise although about 10,000 acres within the watershed are well suited to managed timber crops. Yields of merchantable timber from unmanaged native forests are low and have offered little incentive for exploitation. However, the limited resource sustains a small sawmilling industry in Hilo.

Approximately 97 percent of the state's lumber is imported although the timber crop potential in the state far exceeds the volume now imported. Efforts to develop this potential includes a tree planting program. In addition, exotic species that have been planted for erosion control are showing high growth rates. Native koa may be highly productive under management.

Other locally important agricultural industries include flowers and ornamental plants, mostly for export; and treefern, used for planter poles, fern fiber and related products for growers.

Agricultural land is valued at about $.30/sq. ft. in cropland, in pasture, and in wooded areas. Residential areas are valued at $1.50/sq. ft. Significant reductions (above 30 percent) occur in severe water problem areas.

The visitor industry has emerged as a major economic force during the past decade. The number of visitors to the island rose from 75,300 in 1962 to 462,800 in 1970. The island of Hawaii hotel inventory for the same period grew from 690 to 3,440 rooms. The room count in Hilo increased from 318 to 1,200. Employment in hotel service and trade correspondingly increased.

Hawaii County became eligible in 1966 to receive assistance under Title 5 of the Public Works and Economic Development Act of 1965. Eligibility resulted from a decline in agricultural employment and an inadequate increase in other jobs, forcing median family income below the national average. The unemployment rate is 7.7 percent. Sponsors have investigated rural economic development opportunities under the Resource Conservation and Development (RC&D) Program, and an application for RC&D funds has been submitted.

The area is served by a network of state and county roads that provide good access to the watershed. Hilo serves as the primary business and transportation center for the island. General Lyman Field, the state-operated airport located near the coast just south of the watershed, can accommodate modern commercial jet aircraft. In 1967, the airport became a major gateway (second only to Honolulu) to the state. Two inter-island airlines provide frequent daily flights for passengers as well as agricultural products and other cargo. Hilo Harbor provides inter-island barge and container service for sugar, cattle, agricultural exports, and capital and consumer goods imports.

Fish and Wildlife Resources

Mullet (Mugil cephalus), awa (Chanos chanos) and aholehole (Kuhlia sandvicensis) are plentiful in the Wailoa River and Waiakea Pond, a 26-acre brackish water pond located at sea level. The Waialama Canal, which outlets into Waiakea Pond, also supports similar but fewer of these fish resources.

The Wailuku River and its tributaries which drain most of the watershed, support several animal resources. According to a survey made in 1966 and 1967 by the State Division of Fish and Game, the following resources were found: atyid shrimp (Atya bisulcata), river shrimp (Macrobrachium grandimanus), crayfish (Procambarus clarkii), guppy (Lebistes reticulatus) and goby (Siujdium stimpsoni). These resources were described as fair to abundant at elevation 1,480 feet except goby which was described as few. None of these resources were found at elevation 3,360 feet.

Hilo Bay supports a variety of fish species. In a survey [2/] made by Neighbor Island Consultants in 1972, they identified 72 species of fish found in the Bay. According to their report, some of the abundant species are: manini (Acanthurus sandvicensis), palani (Acanthurus dussumieri), nehu (Stolephorus purpureus), weke (Mulloidichthy samoensis), butterfly fishes (Chaetodon sp.), 'o'io (Albula vulpes), mullet (Mugil cephalus), kupipi (Abudefduf sordidus), papio (Caranx ignobilis) and aholehole (Kuhlia sandvicensis). Portunid crab (Portunus sanguinolentus) and red crab (Podopthalmus vigil) are also abundant.

Wild pigs, sheep, and goats are found in the watershed. Pigs occupy primarily the rain forests and the higher elevation forests at timberline. Sheep and goats occupy the more isolated habitats, open and scrub forests on the higher moutain slopes.

Several species of game birds have been successfully introduced into the watershed. These include the ring-necked pheasant, chukar partridge, lace-necked dove, barred dove, grey francolin, California quail, and Gambel's quail. Most of these are found in the grasslands and the drier open forests above 5,000 feet.

Some of the representative species of other birds present in the watershed include the Pueo (Asio flammeus sandwichensis), Hawaii Amakihi (Loxops virens virens), Apapane (Himatione sanguinea sanguinea), and Hawaiian hawk (Buteo solitatius).

The following avian species, which are present in the watershed, are listed in "Threatened Wildlife of the United States," 1973 Edition and revisions, published by the U.S. Bureau of Sport Fisheries and Wildlife:

Hawaii nukupuu	Hemignathus wilsoni
Hawaii akepa	Loxops coccinea coccinea (Gmelin)
Ou	Psittirostra psittacea
Hawaiian goose	Branta sandvicensis
Hawaiian hawk	Buteo solitatius
Hawaiian bat	Lasiurus cinereus semotus
Hawaii creeper	Loxops maculata mana

None of the above listed species, except the Hawaiian hawk, are known to be in the area where structural improvements are planned.

2/ Neighbor Island Consultants, Baseline Environmental Investigation of Hilo Harbor, March 1973.

Recreational Resources

Twenty-six parks, including five in the watershed, are within 15 minutes of Hilo. These include 18 inland parks, one resort hotel park with boat launch, and four beach parks, according to the State Comprehensive Outdoor Recreational Plan (SCORP). No potential parks or recreational areas in the watershed are included in SCORP. However, the county plans to develop a lagoon and recreational park in a 50-acre area along Waialama Canal. The state is developing a park along the Wailuku River between Boiling Pots and Peepee Falls (see Project Map).

Wailuku River, carved into lava, has many scenic locations such as Rainbow Falls, Boiling Pots, and spectacular river crossings.

The Wailuku and Wailoa Rivers, Waiakea Pond, Waialama Canal and Hilo Bay are used for recreational fishing.

Other scenic attractions include numerous lava fields in the upper watershed and Kaumana Cave, a large lava tube along Kaumana Drive. Forest lands also offer a variety of recreation opportunities--hiking, hunting, bird watching, and picnicking.

Archeological Resources

The "National Register of Historic Places" lists no archeologically important sites in the watershed. The Division of State Parks reports no sites of archeological significance in the project construction areas.

An archeological walk-through survey of selected areas in the watershed was made on June 19, 1975, by Aki Sinoto and Neal Oshima (Bernice P. Bishop Museum), and Owen Narikawa (a volunteer). The survey included the strip of land along Structures 3, 4 and 6 and the outlet of Structure 5. Two sites were located, all in the area of Structure 4. The surveyors determined these sites to have only marginal significance.

Soil, Water and Plant Management Status

Woodlands in the watershed are being developed for urban use with most of this activity taking place below Akolea Road (see Project Map). Urbanization has not affected sugarcane land because the industry has committed itself to keeping 95 percent of its land in cane as a condition for securing financing for improvements in the processing mill.

SCS, through the two SWCDs, assists land owners and operators with conservation treatment on the land. There are 76 SWCD cooperators who control 95 percent of the watershed area; 14 have conservation plans covering 33,120 acres. About 10 percent of the planned land treatment measures are presently applied. About 390 acres of cropland, 20,000 acres of pastureland, 10,000 acres of forest land, and 570 acres of urban land are considered adequately treated or protected.

WATER AND RELATED LAND RESOURCE PROBLEMS

The principal watershed problems consist of erosion, sediment and flood damage to agricultural lands, residential areas, and commercial developments; and sediment pollution of Wailuku River, Alenaio Stream, and Hilo Bay.

Land Treatment

Erosion and sediment damage in the sugarcane fields occurs on both sides of the Wailuku River. When sugarcane harvesting was done by hand, crop residue left on the ground provided protection against soil loss. Machine harvesting eliminates much of this residue, leaving the fields bare for up to six months before new cane provides significant protective cover. Soil compaction by machinery during harvesting and other operations reduces infiltration and percolation which intensifies runoff and erosion. During each storm, topsoil is lost from cultivated fields requiring repairs to field roads and reestablishment of sugarcane.

Land treatment problems in the caneland are caused by a combination of ownership patterns and the lack of a cover to protect the bare soil during the initial months of cane growth. At the present time, there isn't any recommended cover crop for caneland, and harvesting machinery that retains the cane leaves in the fields is still being developed. The cane trash left in the field will provide an excellent protective cover to the bare soil.

The land owners and operators are financially able to install land treatment measures, but their application has been difficult in parts of the sugarcane lands because of the complicated land ownership patterns. Such measures as in-field diversions have to cross the boundary lines of many small properties and leases. A coordinated group effort has been lacking.

Floodwater Damage

The principal floodwater problems consist of damage to agricultural lands and residential and commercial developments. Flooding in the community of Kaumana results from overland flows from the cultivated sugarcane fields and Kaluiiki Branch (see Figure 3A). Below the Kaumana area, damage occurs in the vicinity of Chong's Bridge at Kaumana Drive and along Chong Street (see Figure 3B). This damage is caused by overbank flows from Waipahoehoe Stream in combination with overland flows from the nearby forested lands. Floodwaters damage homes, isolate families, and endanger lives in these residential areas.

Below Chong's Bridge in the nearly flat area where Waipahoehoe Stream becomes Alenaio Stream, floodwaters inundate a large area, including a portion of Kaumana Garden subdivision (see Figure 3C). Inadequate stream and bridge capacities and the meandering of Alenaic Stream cause flooding in the residential and commercial areas of downtown Hilo. Floodwater then flows into the Waialama Canal which has a very low capacity. Floodwater inundates the area from the canal to and including the Bayfront Highway.

Past storms have damaged property and endangered human lives starting at the areas surrounding the Kapiolani Street Bridge and terminating at the Kilauea Street Bridge. These past storms have been destructive in terms of dollars and lives. The extent of a projected 100-year storm flood plain is vast, stretching from Kalakaua Street to Hualalai Street.

Another problem area is along Ainako Stream. Floodwaters overflow, damaging homes, streets, and other improvements and endangering lives (see Figure 3D).

Thirty-three damaging floods have occurred in the past 92 years. Records list the storm of July 1966 as the most damaging, although long-time residents recall other floods of greater magnitude.

The 1966 flood (a 10-year frequency) caused an estimated $356,600 damage, distributed as follows: agricultural, $28,500; residential, $91,200; commercial, $210,000; and public property, $26,900. Three houses and their contents were completely destroyed; two others were moved from their foundations and seriously damaged; and water ranging from 1 inch to 2.5 feet deep entered 140 other houses. Thirty people were evacuated by rescue personnel. A policeman narrowly escaped death when he plunged into the water to escape a falling house and was swept through an 80-foot culvert and several hundred feet down the channel before being rescued. Sixty-eight commercial establishments were heavily damaged by as much as 2 feet of water. Business was suspended by most of these firms while awaiting repair, new merchandise, and supplies.

The flood of January 1969 (a 2-year frequency) caused $18,500 damage, as follows: agricultural, $7,000; residential, $10,500; and commercial, $1,000.

A 100-year storm under present conditions would be expected to cause an estimated $150,000 agricultural, $910,000 residential, $1,623,000 commercial, and $62,000 public property damages. There are 185 homes, 160 commercial firms, and 130 other landowners in the 100-year flood plain (see Figures 3A, B, C, and D).

Average annual damage in the project area above Chong's Bridge is estimated at$10,400 for agricultural crop and pasture, $170,800 for the residential area, and $5,900 for public property damage (Table 5).

Flooding does not restrict land use in canefield and pasture areas but does decrease economic returns and prevents adequate management of these areas.

The present value of developments in the flood plain is about $5 million, but, after completion of planned developments, this could increase to about $8.5 million.

Erosion Damage

The estimated annual erosion rates per acre are:

Cropland	7-11 tons
Pastureland	2-3 tons
Forest land	0.2 ton
Urban and Industrial	4 tons

Most soil loss is from sheet and rill erosion. Streambank erosion is not a serious problem because most streams are contained in bedrock gorges or in well-vegetated streambanks.

The average annual damage from overland flow scour erosion is $58,100 (see Table 5). The flows may not follow the same pattern with each flood; however, most cultivated cropland is consistently damaged. Repairing rill and gully erosion damage and replanting fields decrease crop production and result in lower profits.

In the residential areas, erosion damages gardens and undermines driveways and house foundations.

Sediment Damage

Approximately 160 acres in residential and agricultural areas are damaged by sediment annually. The damage is estimated to be $7,000 for crop and pasture land, $11,000 for residential land, and $3,200 for public property (see Table 5). The estimated average annual sediment yield from the 117,000-acre contributing area is 43 acre feet (0.23 ac. ft. per sq. mi.). About 50,000 acres of the watershed are barren lava and cinderland which is not included in the contributing area.

Alenaio Stream and Wailuku River become very turbid during periods of intense rainfall. The water, turned red by sediment, discharges into Hilo Bay and lowers its quality. When runoff ceases, the water again becomes clear.

Fish and Wildlife

Historically, clearing of native vegetation for cultivation, pasture, and urbanization resulted in loss of habitat for native birds. While protection of vast forest reserve tracts within the watershed since the early 1900's has prevented further habitat loss, it has not prevented damage to many native forest ecosystems by the spread of aggressive exotic vegetation, insect pests, and forest diseases.

Large population of pigs, sheep, and goats, occupying the isolated mountain habitats, have had a detrimental impact on soils and endemic flora and fauna.

There is no known critical native land bird habitat in the areas subject to flooding, sediment, erosion, and poor water quality. On the other hand, waterfowl, fish, and other aquatic life in the canals, estuarine ponds, and coastal areas are adversely affected by flooding, sediment deposition, and pollutants from land and water facilities.

Economic and Social

The double leasing arrangements (Hawaiian Homes Commission lands are leased to Mauna Kea Sugar Company, which in turn leases portions of the land to independent growers), high costs of harvesting and processing, and a 2-year growing period make some of the independent sugarcane growers marginal operators. These conditions have made installation of conservation measures difficult and have required the growers to seek outside employment in the construction or the tourist-related service industries. As expenses for the independent growers rise and their return decreases, additional employment opportunities will be needed to maintain a sufficient standard of living. The family farms, maintained after work and on weekends, use little or no hired labor. Approximately 0.1 percent of the benefited area is devoted to farms using more than 1-1/2 man-years of hired labor.

PROJECTS OF OTHER AGENCIES

The County of Hawaii, as a part of its local drainage improvement program, has plans to construct a small diversion above the Ainako residential area to intercept water originating from the lands below Akolea Road. The county's plan is compatible and enhanced by measures in this plan.

Other county projects within the watershed area which are planned or completed are:

Planned: (1) A project to reduce flooding in the Kaumana Garden subdivision.

(2) Channel work on Alenaio Stream between Komohana Road and Kapiolani Street, designated as Reach 2 on Project Map, and a diversion at Komohana Road also shown on the Project Map.

Completed: (1) Manuelele diversion in the Ainako area.

(2) A storm drain from Naauao Street to Waipahoehoe Stream.

PROJECT FORMULATION

The project work plan was based on objectives of sponsoring local organizations and interested agencies and individuals.

The Kaumana-Piihonua Flood Control Citizens Committee worked for a year gathering data, holding meetings, and, with the Waiakea and Mauna Kea SWCDs, prepared an application for assistance under Public Law 566. The application was approved on February 21, 1967, and planning authorization was received on December 9, 1969.

Three public meetings were held during project planning. They were held to present a progress report, a land treatment program and the structural measure alternatives and costs, and to obtain public approval. Numerous other meetings were held with the soil and water conservation districts and the County Public Works and County Planning departments to coordinate activities during the planning process.

Initial investigations of the watershed included studies of the flooding problems in the entire Kaumana-Piihonua area, including downtown Hilo. It was found that protection of the downtown area would involve very high costs, and the benefits would be primarily urban. No feasible sites for retarding flood flows were found. Channel work and associated non-structural measures that could be better undertaken by local entities appeared to be the best solution. Accordingly, protection of this area was not included in the sponsors' objectives for the watershed project.

The county investigated means for the protection of this area. The county requested the Corps of Engineers to study the area and evaluate the possibilities of a Corps project for controlling floods. The project appeared feasible and can be undertaken when local funds become available.

Objectives

Specific objectives which have been agreed upon by the sponsors and SCS are as follows:

1. To install needed land treatment measures as the first increment of the project for watershed protection and flood prevention.

2. To reduce average annual soil loss on cropland to not more than five tons per acre per year.

3. To protect the agricultural land and residential area of Ainako, Kaumana, and Chongmanville against flood damage from a 4 percent and 1 percent chance storms, respectively.

4. To maintain wildlife habitat.

Environmental Considerations

The environmental considerations were evaluated for the works of improvement for each site. Care was exercised in each site selection to minimize environmental damage and intrusion into the landscape. The visual quality of the area was considered to be sure that structural measures would not detract from the natural landscape. Consideration was given to the quality of the water to be diverted to Wailuku River and Waipahoehoe Stream. Also, the effect of the addition of the diverted water on the flow of the main streams was analyzed.

Alternatives

The following alternatives, some of which could not be carried out under the authority of PL-566, were considered as solutions to the problems identified at the onset of planning:

1. Accelerated Land Treatment Only

Accelerated conservation land treatment measures would be applied to about 3,490 acres of cropland, 13,850 acres of pastureland, 1,200 acres of urban land, and 10,000 acres of forest land. Typical land treatment measures that would be applied to the various land uses are:

Cropland: Crop residue management, conservation cropping system, in-field diversions, stream channel stabilization, streambank protection, critical area planting, grade stabilization structures.

Pastureland: Pasture management, brush management, pasture planting.

Urban land: Replanting denuded areas, diversions, holding ponds.

Forest land: Reforestation, insect and disease control, fire control and fire prevention.

The conservation land treatment measures would protect the agricultural land from the 25-year storm and would reduce the average annual flood damages by about 5 percent. The sediment yield, by land use, would be reduced as follows: 66 percent on cropland, 28 percent on pasture, and 55 percent on urban land. Storm runoff would not be reduced significantly, and flooding would continue. The cost of this alternative is estimated at $1,885,000.

2. Accelerated Land Treatment, Flood Plain Zoning, Flood Proofing, and Flood Insurance

The land treatment measures would be installed, and their impact and effect would be the same as the "Accelerated Land Treatment Only" alternative.

Flood plain zoning which regulates residential construction would keep future damages to a minimum. Regulations would require flood control structures or flood proofing measures in new residential constructions as a prerequisite to issuance of building permits. In some areas where the flood hazard is great, the government would buy these properties for open space use, depending on the community needs. These areas could also be rezoned for pasture, orchard, and similar uses where flooding would cause minor amounts of damage.

Flood proofing of existing buildings would be of the permanent type because of the inability of forecasting the occurrence of damaging floods in time to install contingent flood proofing structures. Example of permanent type installation would include solid wall and earth dikes upstream of individual houses. Such installation would effectively divert floodwater from the protected property.

This method of flood proofing would be possible only to some houses because of their orientation with direction of flood flows. Also, these flood proofing walls would divert water into neighboring properties and streets. Damages to unprotected areas would increase. Streets would be impassable during flooding and floodwater would continue to be a threat to life and property.

Flood proofing in future construction would require building floors above flood levels.

Flood insurance, presently available for those who can afford to buy it, will offset monetary losses to property owners. Insurance will not relieve the distress and anxiety of those caught in the flood nor can it fully compensate for loss of life or property.

The cost of this alternative is estimated at $5.3 million.

3. Accelerated Land Treatment, Floodwater Diversions, and Channel Work

This alternative includes the land treatment measures described in the "Accelerated Land Treatment Only" alternative.

The structural measures consist of:

a. A floodwater diversion at Akolea Road, extending from Waipahoehoe Stream to the Wailuku River.

b. A floodwater diversion about 1,600 feet downstream from the road to Lyman Springs. This diversion will extend from Kaumana Drive to Waipahoehoe Stream.

c. A floodwater diversion upstream from Wilder Road. This diversion will extend from the housing area to Kaluiiki Stream.

d. A floodwater diversion upstream from Chongmanville and channel work in the vicinity of Chong's Bridge.

This alternative would protect all the agricultural land below the structures and will provide a 100-year level of protection to the urban areas of Kaumana, Ainako, and Chongmanville.

The estimated cost of this alternative is $5.1 million.

4. No Project Alternative

This alternative would leave the agricultural areas and residential areas of Chongmanville, Kaumana, and Ainako vulnerable to floodwater, sediment, and erosion damages. Flood plain residents can purchase federally subsidized flood insurance through the Federal Insurance Administration. Flood insurance does not provide flood protection but rather is a means of recovering a portion of a flood loss. Flood insurance would cost each residence approximately $115 per year.

The on-going land treatment program will continue at its present level of installation.

The net average annual benefits forgone by not implementing the project would be about $208,450.

The selected plan provides a more complete protection for the agricultural areas and urban areas of Ainako, Kaumana, and Chongmanville than alternatives 1, 2, and 4 and a similar protection as alternative 3 but costs $2.1 million less. The plan consists of channel work in existing streams except that diversions are planned in areas where overland flow causes the major damage and in areas where channel work would require relocation of homes. Unlike alternative 3, where Waipahoehoe Stream would be diverted to Wailuku River, this plan would not divert floodwater from one drainage basin to another.

The flood plain from about 900 feet downstream from Chong's Bridge to Hilo Bay will not be protected by the project and will remain subject to flooding. This area includes the undeveloped brushland between Chong's Bridge and Komohana Road and a portion of downtown Hilo along Alenaio Stream and the Waialama Canal. Flood damage reduction in these areas is partially provided by the federally subsidized flood insurance program.

The County of Hawaii, under its authority of approving plans, requires the incorporation of flood prevention measures in the subdivision plans in flood hazard areas. In areas along Alenaio Stream and Waialama Canal, the insurance program will partially offset future flood losses. The U. S. Army Corps of Engineers has completed a flood control study for this area which proved feasible.

WORKS OF IMPROVEMENT TO BE INSTALLED

Land Treatment Measures

The Mauna Kea and Waiakea SWCDs are progressive districts with favorable existing programs and district cooperators using agricultural land within its capabilities and treating it according to its needs. Projected needs for these programs total $1,122,400.

Accelerated application and continued maintenance of land treatment measures is necessary so that other improvements will produce the expected benefits. Therefore, in addition to presently available technical assistance, $90,000 in federal funds will be made available under authority of Public Law 566 to accelerate planning of these measures. Approximately 1,600 acres of cropland and 4,000 acres of pastureland will be treated.

Examples of cropland treatment measures include:

-- Crop residue management - Using plant residues to protect cultivated fields during critical erosion periods.

-- Conservation cropping system - Growing crops in combination with needed cultural and management measures.

-- In-field diversions using channels to transport runoff water from areas of concentration and carry it at safe velocities to protected outlets.

-- Stream channel stabilization - Stabilizing the channel of a stream with structures.

-- Grade stabilization structures - Stabilizing the grade or controlling a head cut using structures in natural or artificial channels.

-- Streambank protection - Stabilizing and protecting banks of existing streams against scour and erosion by vegetative or structural means.

-- Critical area planting - Planting vegetation such as trees, shrubs, vines, grasses, or legumes on critically eroded areas.

Examples of pastureland treatment measures include:

-- Pasture management - Proper grazing of pastureland.

-- Pasture planting - Establishing and re-establishing long-term stands of adapted species of perennial, biennial, or reseeding forage plants.

-- Brush management - Managing and manipulating stands of brush by mechanical, chemical, or biological means.

Urban land treatment:

Permits to clear land for urban use will require measures to minimize erosion and runoff. These measures, which may be temporary or permanent, include replanting denuded lands with proper vegetation and providing diversions, holding ponds, and similar measures to keep the soil on the land. Also, only a limited number of acres will be permitted to remain open at any one time. A total of 1,200 acres will be treated.

Forest land treatment measures:

Land treatment measures on forest land are designed to increase productivity for forest products, recreation, and wildlife habitat while maintaining the present generally favorable watershed condition and protecting ecosystems of natural flora and fauna.

There are no critical land stabilization needs on forest land in the watershed. The current program for management of state forest land and technical assistance presently available to private forest landowners under the Cooperative Forest Management Program will be adequate during the project period. No accelerated program is anticipated under this project. A total of 10,000 acres will be treated.

Typical measures include:

1. Reforestation or improvement of forest cover to protect the soil, reduce runoff, and enhance timber, scenic, recreation, and wildlife resources.

2. Maintain favorable watershed conditions by:

    a. Excluding feral animals from forest reserves and maintaining game animal numbers at acceptable levels.

    b. Keeping burned acreage at acceptable level with effective fire prevention and control program.

    c. Insect and disease control - Continue to evaluate the cause, effect, and, if feasible, implement control for "ohia dieback" and other insect and disease infestations.

Structural Measures

Structural measures will supplement the land treatment program in reducing floodwater erosion and sediment damages. The structural measures consist of four floodwater diversions, stream channel work in Waipahoehoe Stream, and a concrete rubble masonry wall (see Project Map). Tables 1 and 2 list the cost distribution of the proposed measures by types and by individual structure systems. Table 3 lists the design features of the various structural measures.

Structure 6 (see Figure 4) consists of a rock and earth cut trapezoidal floodwater diversion with provisions to trap debris. The diversion to Waipahoehoe Stream will be approximately 4,020 feet long with a bottom width of 8 feet for the first 1,000 feet and 25 feet thereafter. Depth will range from 5 to 11 feet. Side slope will be 1:4 (1 horizontal to 4 vertical). The diversion will be constructed through pastureland and woodland with topsoil 10 to 12 inches deep over lava rock. Pockets and layers of soil and highly fractured rock may be encountered during excavation. Pneumatically applied mortar will be used to line these areas. The area is expected to contain lava tubes, some with flowing water. When a tube carrying water is intercepted during construction, the water will either be bypassed or introduced into the diversion. This structure will intercept runoff from forest lands and will protect sugarcane fields and the residential areas above Kaumana. It will be designed to contain the 100-year peak flow estimated at 290 cfs for the reach up to Station 12+50 and 1,780 cfs for the remainder of the diversion.

A 13-foot-wide maintenance road will run parallel to the diversion on the downhill side. About 4.5 acres of grazed woodland will be required for the right-of-way and construction of the diversion. Displacement of people, businesses or farm operations is not anticipated. Soil erosion and water and air pollution will be minimal in this rocky area. No major erosion or pollution problems are expected.

Structure 5 (see Figure 5) consists of a trapezoidal floodwater diversion channel that will divert overland flow from Kaumana Drive to Kaluiiki Branch. The diversion will be approximately 1,200 feet long, with a bottom width of 12 feet and depth of 9.4 feet. Side slopes will be 2:1.

This diversion will be excavated in soil underlain by fractured rock. The soil is highly sensitive. The strength and erosion resistance is relatively high in the undisturbed state but extremely low when disturbed. Special care will be exercised during construction, and channel banks will be shaped from the bottom to keep disturbance to a minimum. It will be constructed through sugarcane land and will be vegetated. No maintenance road will be needed since the diversion channel will be maintained from the inside.

It will intercept floodwater from the area below Structure No. 6 to protect the sugarcane fields and residential areas along Kaumana Drive. It will be designed to contain the 100-year peak flow estimated at 1,350 cfs.

A bridge crossing will be constructed on Wilder Road and a ford crossing on the field road.

About 2.0 acres of sugarcane land will be required for rights-of-way and construction of the diversion. Soil erosion and noise and air pollution can be expected during the construction phase. However, vegetating the channel as construction proceeds will minimize the erosion problem.

Structure 4 (see Figure 6) will consist of a rock cut trapezoidal floodwater diversion channel that will divert overland runoff into Wailuku River. This diversion will be approximately 4,050 feet long with a bottom width of 10 feet and a depth of 13 feet. Side slopes will be 1:4. As in Structure 6, lava tubes may be encountered during excavation. It the tube feeding Ainako Stream is intercepted, a bypass structure will be provided to release low flows into the stream.

This diversion will be constructed on pastureland and urban-zoned land. Soils with a high level of organic material are about 10 inches deep over lava rock. Highly fractured rock may be encountered during excavation. Pneumatically applied mortar will be used to line these areas. This diversion will intercept floodwater from forest and pasture lands and will protect the Ainako residential area. It will be designed to contain the 100-year flow at 1,120 cfs.

For safety, a fence will be installed along the last 1,130 feet of the diversion.

A 13-foot-wide maintenance road will run parallel to the diversion on the downhill side. A water main will be relocated near Waianuenue Road, and a bridge crossing will be constructed on that road.

About 4.2 acres will be required for the construction of this diversion. As in Structure 6, construction will be in a rocky area and no pollution problems during construction are expected.

Structure 3 (see Figure 7) will consist of a floodwater diversion, a concrete rubble masonry (CRM) wall and channel work in the vicinity of Chong's Bridge.

The diversion will intercept floodwater from the woodland and transport it to Waipahoehoe Stream. It is approximately 2,100 feet long with a bottom width of 8 feet and a depth of 6.7 feet. Side slopes will be 1:4. It will be constructed through recently cleared brushland. The soils are less than 12 inches thick over lava rock. Pneumatically applied mortar will be used where soil pockets or highly fractured rocks are encountered.

The channel work on Waipahoehoe Stream consists mainly of removing boulders and trees within the stream proper to increase stream capacity above Chong's Bridge. The 3,500 feet of channel work will remove only those boulders and trees which block or restrict the flood flows. Work will be limited to one bank when possible.

The work will increase the capacity of the stream to contain the 100-year flow except in two sections of the 3,500-foot reach. A CRM wall will be constructed along these sections. An 800-foot-long CRM wall will be constructed downstream of the diversion outlet. This trapezoidal wall will have 7 feet bottom width, 2 feet top width, and 10 feet in height. A similar CRM wall, 200 feet in length, will be constructed downstream from Chong's Bridge. Foundation for these walls will be in rock.

A 13-foot-wide maintenance road will run parallel to the diversion and CRM wall. About 1.5 acres of brushland will be cleared to construct these measures. This structure will protect the residential areas along Chong Street. It will be designed to contain the 100-year flow estimated at 440 cfs for the diversion and 7,080 cfs for Waipahoehoe Stream.

A water main will be relocated at Chong's Bridge. This bridge will be replaced.

Noise of heavy equipment during construction of Structures 3, 4, and 5 may be annoying to residents of the area. Construction specifications will require practices to control erosion and sedimentation during construction, in conformance with the county's erosion control standards.

Important archeological sites are not known to be located in the construction areas. However, should any sites be discovered during either design or construction, the sponsors will notify the Bishop Museum, National Park Service, and the Department of Land and Natural Resources before design or construction continues.

EXPLANATION OF INSTALLATION COSTS

Land Treatment Measures

The total estimated cost for installing land treatment measures is $1,122,400 (see Table 1). The cost to land owners and operators is $885,400. The estimated cost of SCS and Forest Service technical assistance is $132,000. The PL-566 share, estimated at $90,000, will cover accelerated technical assistance expenses to meet the 10-year schedule. The remaining $42,000 will cover SCS, Forest Service, and State Forestry Division costs for normal on-going programs. The State Forestry Division will install land treatment practices on the forest land at a cost of $105,000. These land treatment practices consist of 10 acres of tree planting and disease control throughout the forest land.

These cost estimates are calculated from current cost figures and past experience.

Structural Measures

Tables 1 and 2 show the estimated installation costs for the structural measures. These include costs for construction, engineering services, project administration, and land rights.

Construction costs include the contract costs for earthwork, pneumatically applied mortar and concrete masonry walls in diversions, inlet, and outlet structures. Also included are contract costs for stream work and establishing vegetation on earth-cut diversions. Various elements of construction were separated for each structure, and unit prices paid for similar elements of work on recent projects were used to estimate construction costs. These estimated costs were increased by 20 percent for contingencies. The total estimated construction cost for flood prevention is $1,108,500 and will be borne by PL-566 funds.

Engineering costs include those for engineering and geologic investigations, surveys, structural design, and related activities. The total estimated engineering cost of $221,750 will be borne by PL-566 funds.

Project administration cost includes expenditures for contract administration, construction surveys, review of engineering plans prepared by others, and construction inspection services. It also includes costs for relocation advisory services and administrative functions connected with relocation payments. The sponsors will provide all relocation advisory services. Administrative duties associated with relocation payments will be provided as needed by the SCS and sponsors. No relocation of any person, business, or farm operation is anticipated. Total project administration cost is estimated at $279,550 of which $221,750 is borne by PL-566 funds and $57,800 by others.

The total estimated land rights cost of $289,000 will be covered by other funds. Of this amount $164,550 is for land acquisition; $5,350 for survey, legal fees, and other costs; $91,800 for channel crossings (two in Structure 5, one in Structure 4, and replacement of Chong's Bridge); $16,000 for utility replacement necessitated by construction of Structures 3 and 4; and $11,300 for fence.

The estimated funds needed for installation of the project are tabulated below:

Fiscal Year	Activity	Funds (Dollars)		
		PL-566	Other	Total
First	Land Treatment	9,000	103,240	112,240
	Structural	523,850	220,800	744,650
Second	Land Treatment	9,000	103,240	112,240
	Structural	517,000	106,500	623,500
Third	Land Treatment	9,000	103,240	112,240
	Structural	511,150	19,500	530,650
Fourth	Land Treatment	9,000	103,240	112,240
Fifth	Land Treatment	9,000	103,240	112,240
Sixth	Land Treatment	9,000	103,240	112,240
Seventh	Land Treatment	9,000	103,240	112,240
Eighth	Land Treatment	9,000	103,240	112,240
Ninth	Land Treatment	9,000	103,240	112,240
Tenth	Land Treatment	9,000	103,240	112,240
Total Land Treatment		90,000	1,032,400	1,122,400
Total Structural		1,552,000	346,800	1,898,800
TOTAL PROJECT COST		1,642,000	1,379,200	3,021,200

EFFECTS OF WORKS OF IMPROVEMENT

The proposed land treatment and structural measures provide an integrated approach to reduce floodwater, erosion and sediment damage to agricultural and urban lands. These measures will improve agricultural operations and protect lives and homes in the watershed.

Cropland measures increase soil water intake, stimulate plant growth, and minimize soil erosion. Application of good pasture treatment practices will likewise promote better forage and provide soil protection. These land treatment measures will reduce floodwater, sediment, and erosion damages by approximately 3 percent annually.

The forest land measures will maintain the presently favorable watershed conditions and improve wildlife habitat, recreation, and forest productivity.

With the structural measures, a total of 970 acres, about 560 people, 136 homes, and 10 diversified agricultural operations will be benefited.

After installation of the project measures, a storm comparable to the 1966 storm (a ten-year event) would cause only minor damage to the agricultural lands and grazed woodlands adjacent to the streams. Floodwater damages from a 100-year storm will be limited to about 120 acres adjacent to the streams and consisting of grazed woodland and agricultural lands. There will be no damages to the residential areas of Ainako, Kaumana, and Chongmanville from either storm.

The project measures will not have any measurable effect on floodwater damage in existing flood prone area downstream of Chong's Bridge. This area includes the broad wooded flood plain of Waipahoehoe and Alenaio Streams and downtown Hilo along Alenaio Stream and Waialama Canal.

In downtown Hilo, the County of Hawaii has plans for flood control measures. When these flood control measures are installed, the flood damage from a 100-year storm will be greatly reduced.

Under its authority of approving subdivision plans, the county requires flood control measures before any developers are allowed to build in undeveloped flood plains.

Special design and construction procedures will minimize soil erosion during construction. Specific vegetative measures will be required for each construction area. All denuded and fill areas will be graded to assure drainage, then fertilized, seeded, and mulched.

After installation of all proposed land treatment measures and practices, the sediment yield, by land use, will be reduced as follows: cropland, 52 percent; pasture, 18 percent; urban, 38 percent. Sediment yield from forest land is at near natural level, and management practices are expected to maintain existing conditions.

Installation of the project will increase the sales and services of retailers, processors, and transporters of agricultural products.

Fish and Wildlife

The proposed project measures will reduce sediment entering Wailuku River, Hilo Bay and Waiakea Pond and will help preserve resources of these waters.

Floodflows diverted by Structure 4 into Wailuku River about 2 miles upstream from where such flows normally enter will not have any effect on the river's fish resources. Flood runoff will be of the same quality as the river's flow originating from forest lands.

About 9.2 acres of grazed woodland and pasture that have limited wildlife value will be lost to the structural measures. This acreage is only one hundredth of one percent of the total woodland. Moreover, most of the game birds in the watershed are found in the grasslands and drier open forests above 5,000-foot elevation. The back slopes of the maintenance road and fill areas will have grass and shrub plantings with wildlife value to replace some of the lost habitat.

Species listed in "Threatened Wildlife in the United States," 1973 Edition, U.S. Bureau of Sport Fisheries and Wildlife, are not known to be in the area except the Hawaiian hawk.

Archeological

Two archeological sites were found in a 600-foot-wide strip along Structure 4. If the design survey indicates that these sites will be disturbed during construction, construction activity leading to their disturbance or destruction will be monitored by an archeologist to record the sites in more detail.

Economic and Social

An immediate benefit resulting from the project installation will be employment for the watershed residents who will construct, operate, and maintain the project measures. Damages caused by storm runoff will be reduced; the economic base will be stabilized; and family farm enterprises will have a higher net return.

The value of lost production from the sugarcane and pasturelands needed for the structural measures is approximately $8,000 per crop for sugarcane and $100 per year for pastureland.

The installation of the project will provide a sense of security and peace of mind for the residents and agricultural operators in the 970-acre benefited area. These factors will contribute to an increase in property value to these 970 acres.

Distribution of the rural population in the watershed will remain relatively constant. There are about 560 people living in the benefited area. No land use changes are expected and no one will be displaced by the project.

Other

Installation of the structural measure will result in the loss of 2.0 acres of sugarcane land, 3.1 acres of pastureland, 6.1 acres of grazed woodland, and 1.0 acre of urban land.

Other unevaluated benefits include improved aesthetic conditions and, most important, protection of human life.

PROJECT BENEFITS

The benefits resulting from the installation of proposed structural measures will amount to $342,200 annually distributed as follows: damage reduction, $292,500; secondary, $30,900; and redevelopment, $18,800 (see Table 6).

Additional damage reduction benefits resulting from the proposed land treatment measures will amount to $8,700 annually.

The estimated average annual loss from floodwater, erosion, sediment, and indirect damages within the benefited area (see Table 5) will be reduced from $305,200 to $4,000 by the proposed project.

Since Hawaii County is designated under the Public Works and Economic Development Act of 1965 as an area of serious unemployment, redevelopment benefits of $18,800 were evaluated.

Local secondary benefits, the net increase of goods and services created by the project, resulting from flood prevention will amount to about $30,900 annually. Secondary benefits from the national viewpoint were not considered pertinent to project evaluation.

COMPARISON OF BENEFITS AND COST

The average annual cost of the structural measures is estimated to be $133,750. Expected annual benefits, excluding secondary benefits, are estimated to be $311,300, or $2.33 for each dollar of cost. Including secondary benefits, annual benefits are estimated to be $342,200, for a benefit-cost ratio of 2.6:1.0 (see Table 6).

PROJECT INSTALLATION

This plan will be put into effect by private, local, and federal groups. Land treatment measures on private and state lands will be installed by operators or owners cooperating with the Mauna Kea and Waiakea SWCDs. Technical assistance will be provided by SCS and the State Division of Forestry in cooperation with the U.S. Forest Service.

The structural measures will be installed by the County of Hawaii with assistance from SCS.

The sponsoring local organizations and SCS have agreed to the following responsibilities:

The Mauna Kea and Waiakea Soil and Water Conservation Districts will:

1. provide leadership for accelerated installation of the land treatment measures, and

2. provide leadership and direction to continue the conservation program of the district.

The districts will give first priority to the project during the installation period.

The County of Hawaii will:

1. survey, acquire, and record all necessary land, easements, and rights-of-way for the structural measures prior to releasing an invitation to bid;

2. act as contracting local organization for the construction of the structural measures. If, during the installation period, federal administration of contracts is desired, the County of Hawaii will make necessary arrangements with the SCS;

3. obtain the necessary permits for surveys and investigations required for design purposes;

4. design, install, and maintain all bridges and road crossings required;

5. provide for the installation, operation, and maintenance of all structural measures;

6. furnish the non-federal share for other costs including modification of utilities and improvements, except for land treatment costs identified as land owner or operator costs;

7. draw up agreements between the sponsors and SCS covering all responsibilities of all parties, including inspection and maintenance, prior to the release of invitations to bid. Full conformance with state and federal laws and regulations will be the responsibility of the County of Hawaii.

The County of Hawaii, with its power of eminent domain, can form improvement districts and assess taxes, receive gifts and contributions, and issue bonds for county improvements. The required land, easements, and rights-of-way will be acquired by negotiation or, if necessary, by exercising the right of eminent domain. Appraisals will be based on the market value of similar lands recently sold and the appraised value for tax purposes. With the sponsors' agreement to use such powers, PL-566 assistance for construction may be provided after a court order has been issued for the transfer of lands.

The sponsoring local organizations have given SCS assurance that their share of project costs will be available and that acquisition of land rights for the first two years of construction will begin as soon as possible.

The Soil Conservation Service will:

1. furnish technical assistance through the Mauna Kea and Waiakea SWCDs to landowners for installation of land treatment measures;

2. furnish engineering survey and design services for all structural measures;

3. furnish project administration services to assure that structural works will conform to acceptable standards;

4. allot construction money to the project in accordance with the Schedule of Installation (see page 37) or as revised by mutual agreement and in accordance with national priorities and availability of appropriations at the time of installation;

5. maintain liaison and coordinate action with the sponsors, state, and other federal agencies concerned with the project, and

6. assist the sponsoring local organizations in making needed revisions to the plan.

The schedule for installation of the structural measures follows.

SCHEDULE FOR INSTALLATION OF STRUCTURAL MEASURES

WAILUKU-ALENAIO WATERSHED, HAWAII

Structure		Item	Fiscal Year		
Location	Number		First	Second	Third
Above Ainako Area	4	Design Land Acquisition Construction			
Chong's Bridge Area	3	Design Land Acquisition Construction			
Kaumana Area	5 6	Design Land Acquisition Construction			

NOTE: Construction time shown includes time for advertising bids and awarding contract.

Other state and federal agencies, by agreement with the sponsors, will participate as follows:

The U.S. Forest Service will:

1. cooperate with the State Forester in providing tree planting stock, and

2. furnish technical assistance for land treatment on all non-federal forest land.

The State of Hawaii Department of Land and Natural Resources will:

1. through its Division of Water and Land Development, assist the sponsors as needed to accomplish the work plan, and

2. through its Division of Forestry, in cooperation with the U.S. Forest Service, provide technical assistance in reforestation of state and private forest land.

FINANCING PROJECT INSTALLATION

Land Treatment Measures

Land owners and operators within the watershed will install land treatment measures on crop, pasture, forested, and urban lands. The cost of installing these measures will be borne by the owners and operators of these lands. Cost-sharing assistance to cooperators is available through U.S.D.A. Agricultural Conservation Program (ACP).

Structural Measures

The County of Hawaii has the authority to carry out, maintain, and operate flood control projects. Through its Capital Improvement Projects budget, necessary funds will be requested to carry out the county's obligations, and use of loan provisions of the Watershed Protection and Flood Prevention Act is not anticipated.

Prior to entering into agreements that obligate funds of the Service, the County of Hawaii will have a financial management system for control, accountability, and disclosure of PL-566 funds received, and for control and accountability for property and other assets purchased with PL-566 funds.

Program income earned during the grant period will be reported upon the sponsor's request for advance or reimbursement from the Service.

Federal financing assistance for carrying out these works of improvement will be provided by authority of Public Law 566 (Watershed Protection and Flood Prevention Act, 83d Congress; 68 Stat. 666, as amended). Financial assistance is contingent upon appropriation of funds for these purposes.

PROVISIONS FOR OPERATION AND MAINTENANCE

Land Treatment Measures

Land treatment measures will be maintained by the owners and operators of the lands on which they are installed. Technical assistance for the maintenance of the measures will be provided by SCS through the soil and water conservation districts and by the State Division of Forestry.

Structural Measures

The operation and maintenance of structural measures will be the responsibility of the County of Hawaii. An Operation and Maintenance Agreement between the County, SWCD's and SCS will be executed before the project agreement is signed.

The operation and maintenance agreement will include specific provisions for retention and disposal of property acquired or improved with PL-566 financial assistance.

The County of Hawaii will be responsible for obtaining rights-of-entry or other instruments to allow access to the easements or rights-of-way of the structures. Access to these areas will be solely for operation, maintenance, and inspection.

The maintenance program will include preserving design capacities of channels and inlet structures, and repairing concrete lining that becomes damaged. Debris and unwanted vegetation will be removed periodically. Special care will be exercised when maintaining Structure 5 so as not to disturb the channel banks.

The total estimated annual cost for operation and maintenance is $17,140 (see Table 4).

Some damage to the structures during infrequent floods may occur. Cost for repair of such damage will be a maintenance cost.

An O&M plan will be prepared for each structural measure. The plan will be prepared following guidelines found in SCS, Hawaii, Watershed Operation and Maintenance Handbook.

The County of Hawaii, SWCD's, and SCS will jointly inspect all structures annually and after severe floods for the three-year establishment period following installation of each structure. Annual and other inspections after the third year will be made by the County of Hawaii and a report will be submitted to SCS Hilo Field Office, stating corrective measures needed and actions taken.

TABLE 1 - ESTIMATED PROJECT INSTALLATION COSTS

WAILUKU-ALENAIO WATERSHED, HAWAII

Installation Cost Item	Unit	Number	Estimated Cost (Dollars)[1/]						
			P.L. 566 Funds			Other			Total
			Non-Fed. Land			Non-Fed. Land			
			SCS[3/]	FS[3/]	Total	SCS[3/]	FS[3/]	Total	
LAND TREATMENT									
Land Areas[2/]									
Forest Land	Ac.	10,000	--	--	--	--	135,000[4/]	135,000	135,000
Cropland	Ac.	1,600	--	--	--	114,000	--	114,000	114,000
Pastureland	Ac.	4,000	--	--	--	130,900	--	130,900	130,900
Urban	Ac.	1,200	--	--	--	610,500	--	610,500	610,500
Technical Assistance			90,000	--	90,000	30,000	12,000	42,000	132,000
TOTAL LAND TREATMENT	Ac.	16,800	90,000	--	90,000	885,400	147,000	1,032,400	1,122,400
STRUCTURAL MEASURES[5/]									
Construction									
Floodwater Diversions	Ft.	11,270	801,850	--	801,850	--	--	--	801,850
Stream Channel Work (N) (Incl. CRM wall)	Ft.	3,500	306,650	--	306,650	--	--	--	306,650
Subtotal Construction	Ft.	14,770	1,108,500	--	1,108,500	--	--	--	1,108,500
Engineering Services			221,750	--	221,750	--	--	--	221,750
Project Administration									
Construction Inspection			66,500	--	66,500	26,000	--	26,000	92,500
Other			155,250	--	155,250	31,800	--	31,800	187,050
Subtotal Administration			221,750	--	221,750	57,800	--	57,800	279,550
Other Costs									
Land Rights			--	--	--	289,000	--	289,000	289,000
Subtotal Other			--	--	--	289,000	--	289,000	289,000
TOTAL STRUCTURAL MEASURES			1,552,000	--	1,552,000	346,800	--	346,800	1,898,800
TOTAL PROJECT			1,642,000	--	1,642,000	1,232,200	147,000	1,379,200	3,021,200

1/ Price base: 1976

2/ Includes only areas estimated to be adequately treated during project installation period. Treatment will be accelerated throughout the watershed, and dollar amounts apply to total land area, not just to adequately treated areas.

3/ Federal agency responsible for assisting in installation of works of improvement.

4/ Contains $30,000 for practices to be installed by private landowners. Remainder for practices to be installed by the State Forestry Division.

5/ Type of channel before project: (N) - an unmodified well-defined natural channel or stream.

TABLE 1A - STATUS OF WATERSHED WORKS OF IMPROVEMENT

WAILUKU-ALENAIO WATERSHED, HAWAII

Measures	Unit	Applied To Date	Total Cost (Dollars) 1/
LAND TREATMENT			
Conservation Cropping System	Ac.	260	1,800
Crop Residue Management	Ac.	100	600
Land Smoothing	Ac.	15	1,050
Diversion	Ft.	1,000	1,000
Stream Channel Stabilization	Ft.	4,350	197,300
Pasture Management	Ac.	2,350	94,000
Pasture Planting	Ac.	1,200	96,000
Brush Management	Ac.	1,000	30,000
Trough and Tank	No.	60	3,600
Pipeline	Ft.	2,100	1,050
Hillside Ditch	Ft.	42,300	126,900
STRUCTURAL MEASURES			
Streambank Protection	Ft.	150	15,000
TOTAL			568,300

1/ Price base: 1976

March 1976

TABLE 2 - ESTIMATED STRUCTURAL COST DISTRIBUTION

WAILUKU-ALENAIO WATERSHED, HAWAII

(Dollars)[1/]

Item[2/]	Installation Cost - P.L. 566 Funds			Installation Cost - Other Funds		Total Installation Cost
	Construction	Engineering	Total P.L. 566	Land Rights	Total Other	
#6 Floodwater Diversion	359,300	71,850	431,150	63,050	63,050	494,200
#5 Floodwater Diversion	66,650	13,350	80,000	34,400	34,400	114,400
#4 Floodwater Diversion	322,750	64,550	387,300	101,350	101,350	488,650
#3 Floodwater Diversion	53,150	10,650	63,800	18,000	18,000	81,800
Stream Channel Work (N)	306,650	61,350	368,000	72,200	72,200	440,200
(Includes CRM Wall)						
Subtotal	1,108,500	221,750	1,330,250	289,000[3/]	289,000	1,619,250
Project Administration	--	--	221,750	--	57,800	279,550
GRAND TOTAL	1,108,500	221,750	1,552,000	289,000	346,800	1,898,800

1/ Price base: 1976

2/ Type of channel before project: (N) - an unmodified, well-defined natural channel or stream.

3/ Includes $16,000 for utility modification (water and electrical conduits for two bridges), $5,350 for survey, legal fees and other costs, $91,800 for bridge and culvert construction, and $11,300 for fence.

March 1976

TABLE 3 - STRUCTURE DATA

CHANNEL & DIVERSIONS

WAILUKU-ALENAIO WATERSHED, HAWAII

Site (No.)	Length (ft)	Drainage Area (sq mi)	Capacity cfs		Elev. Change (ft)	Channel Dimensions				"n" Value		Velocities fps		Excavation (cu yds)	Type[1] of Work	Before Project	
			Req'd	Design		Hydraulic Slope (ft/ft)	Bottom Width (ft)	Depth of Flow (ft)	Side Slope	Aged	As Built	Aged	As Built			Type of Channel[2]	Flow Condition[3]
Diversion 6	1000	0.20	290	290	21.0	0.021	8	4.0	1:4	0.045	0.045	8.1	8.1	2,140	I	-	E
	3020	1.97	1780	1780	12.7	0.0042	25	9.5	1:4	0.045	0.045	6.9	6.9	33,398	I	-	E
Diversion 5	1200	0.28	1350	1350	1.9	0.0017	12	8.8	2:1	0.035	0.025	5.2	6.7	10,580	I	-	E
Diversion 4	4050	1.15	1120	1120	37	0.009	10	10.8	1:4	0.045	0.045	8.2	8.2	25,920	I	-	E
Diversion 3	2100	0.07	440	440	42	0.02	8	5.4	1:4	0.045	0.045	8.7	8.7	6,100	I	-	E
Channel Work	750	5.11	4100	4100	18	0.024	varies	varies	varies	0.045	0.045	11.0	11.0	1,300	II & III	N	E
	2750	6.50	7080	7080	66	0.024	"	"	"	0.045	0.045	10.5	10.5	4,700	II & III	N	E

1/ I. Establishment of new channel including necessary stabilization measures.
II. Enlargement of realignment of existing channel or stream.
III. Cleaning out natural or manmade channel (including bar removal and major channel work operations).

2/ N - An unmodified, well-defined natural channel or stream.

3/ E - Ephemeral: Flows only during periods of surface runoff, otherwise dry.

March 1976

TABLE 4 - ANNUAL COST

WAILUKU-ALENAIO WATERSHED, HAWAII

(Dollars)[1/]

Evaluation Unit	Amortization of Installation Cost[2/]	Operation and Maintenance Cost	Total
1[3/]	69,430	11,960	81,390
2[4/]	30,010	5,180	35,190
Project Administration	17,170	--	17,170
GRAND TOTAL	116,610	17,140	133,750

1/ Price base: 1976

2/ One hundred years at 6-1/8 percent interest.

3/ Includes structural measures 3, 5, and 6.

4/ Includes structural measure 4.

March 1976

TABLE 5 - ESTIMATED AVERAGE ANNUAL FLOOD DAMAGE REDUCTION BENEFITS

WAILUKU-ALENAIO WATERSHED, HAWAII

(Dollars)[1/]

Item	Estimated Average Annual Damage[3/]		Damage Reduction Benefit
	Without Project	With Project	
Floodwater			
Agricultural	10,400	200	10,200
Nonagricultural:			
Residential	170,800	--	170,800
Public property[2/] and utilities	5,900	--	5,900
Subtotal	187,100	200	186,900
Sediment			
Agricultural	7,000	100	6,900
Nonagricultural:			
Residential	11,000	1,400	9,600
Public property[2/] and utilities	3,200	--	3,200
Subtotal	21,200	1,500	19,700
Erosion			
Agricultural	17,400	200	17,200
Nonagricultural:			
Residential	39,100	1,500	37,600
Public property[2/] and utilities	1,600	100	1,500
Subtotal	58,100	1,800	56,300
Indirect	38,800	500	38,300
TOTAL	305,200	4,000	301,200

1/ Price base: 1976 and current normalized price for crop and pasture values. Damages and benefits will accrue from floods of greater magnitude than the 100-year event but were not evaluated.
2/ Also includes emergency police and fire department rescue operations.
3/ Within benefited area (see Project Map).

March 1976

TABLE 6 - COMPARISON OF BENEFITS AND COSTS FOR STRUCTURAL MEASURES

WAILUKU-ALENAIO WATERSHED, HAWAII

(Dollars)

Evaluation Unit	Average Annual Benefits[1]			Total	Average[2] Annual Cost	Benefit Cost Ratio
	Damage Reduction	Secondary	Redevelopment			
1[3]	138,300	15,000	13,300	166,600	81,390	2.0:1.0
2[4]	154,200	15,900	5,500	175,600	35,190	5.0:1.0
Project Administration	--	--	--	--	17,170	--
GRAND TOTAL	292,500[5]	30,900	18,800	342,200	133,750	2.6:1.0

1/ Price base: 1976 and current normalized price for crop and pasture values.

2/ From Table 4.

3/ Includes structural measures 3, 5, and 6 in the Kaumana and Chongmanville areas.

4/ Structural measure 4 in the Ainako area.

5/ In addition, it is estimated that land treatment measures will provide flood damage reduction benefits of $8,700 annually.

March 1976

INVESTIGATIONS AND ANALYSES

Land Treatment

The proposed land treatment measures were determined by SCS, the Hawaii Division of Forestry, the U.S. Forest Service, and local sponsors. SCS soil surveys and land operators' field maps, along with knowledge earned from previous experience, formed the basis for determining treatment needs. These needs conform to standards and specifications set forth in the Technical Guide prepared for use by the Mauna Kea and Waiakea SWCDs.

Surveys and analyses of the forested and brush covered portions of the watershed were done by the Hawaii Division of Forestry and the U.S. Forest Service.

Engineering

Channel hydraulic design was based on SCS manuals such as the National Engineering Handbook (NEH) 5, Hydraulics; Engineering Design Standards, SCS-West States; and Planning and Design of Open Channels, Technical Release No. 25.

Except for some defined draws, the floodwaters will enter the diversions as sheet flow. Therefore, in most cases the peak discharge at the downstream end of various diversion reaches was used as the design capacity for the entire reach.

Dense vegetation and rugged topography made access to the diversion sites difficult and in some locations nearly impossible. Spot cross-sections and slopes were surveyed in the field. Channel design was based primarily on contour maps prepared from aerial photographs. The map scale was 1 inch to 200 feet and the contour interval was 10 feet with 5 feet interpolations. Detailed surveys will determine final design of structural measures. Cost contingencies ranged from 15 percent to 20 percent depending on the intensity of the investigations.

Allowable velocites determined the slope for the diversion channels. A maximum velocity of about 7 feet per second was used for vegetated channels and 12 feet per second for channels cut in rock. These velocities were determined by examining existing streams in the area and some performance tests conducted by the Materials Testing Section, Soil Conservation Service, Portland, Oregon. Channel velocities and "n" values will change as the channels age due mainly to plant growth. These values are shown in Table 3.

Proportioning of the channels depended on the soils. In deep soils, grass-lined slopes of 2:1 were used. Dwarf pangolagrass which grows about 10 inches tall will be used to alleviate mowing. Where the soils are mostly lava rock, an almost vertical side slope of 1:4 will be used in the cut portions of the channel. Existing ditches and channels in the watershed where lava rock is encountered have nearly vertical sides.

Geology

The site locations of the diversions were investigated by surficial inspection, analyzing logs of cesspools, logging open post holes along Akolea Road, and interpreting the soils information for the area. The cesspool logs show that the lava flows are thin and there are layers of ash and saprolite between the flows. The cesspool logs vary considerably between neighboring homes.

Structure #3: The soil in the area is very thin and is underlain by pahoehoe lava. The bottom of the diversion will be in rock. Layers of ash occur in the lava which erodes when exposed to the higher velocity stream flows. This soil was sampled for laboratory testing. The 10 to 12 feet per second velocity anticipated near Chong's Bridge will erode this material where exposed. The resulting pools and irregularities are not expected to be extensive and will have no effect on the proper functioning of the channel.

Structure #4: Open post holes along Akolea Road were logged. The logs show that, generally, there is a foot or more of soil over fractured basalt.

There are many intermittent springs downstream from the proposed site. These springs are fed by water that is trapped between basalt flows and by water flowing in lava tubes.

A large perennial spring is located at the rock quarry which is uphill of the diversion. The spring water goes underground just downslope from Akolea Road. It reappears again about 1/2 mile downslope, in a bamboo thicket.

The proposed outlet will cascade floodwater down the right side of the Wailuku River. The overfall is about 30 feet. At this location, there is a stream emerging from a lava tube at the bottom of the overfall.

Structure #5: According to the soils map, the soils are about 5 feet deep in the area of the diversion. The bottom of the diversion should be in fractured basalt.

One representative undisturbed cube sample of the soil from this diversion was tested in the Materials Testing Section, Portland, Oregon, for the purpose of determining the erosion resistance. The material was found to be highly sensitive. The strength and erosion resistance is relatively high in the undisturbed state but extremely low when disturbed. The use of unconfined compressive strength with the tractive power analysis to determine allowable velocities is not considered valid for these soils. The allowable velocities were determined by

evaluating local performance and by some performance tests conducted by the Materials Testing Section. These velocities are valid for undisturbed conditions and will require special construction techniques to minimize disturbance of the channel perimeter. Vegetation will provide added protection and should be established as soon as possible after construction.

Structure #6: The average depth of the soil in the area is 10 inches. The diversion will generally be in fractured basalt throughout its length. The basalt is inter-layered with ash beds of varying thickness.

Sedimentation

An erosion and sedimentation investigation was made on the Wailuku-Alenaio watershed to determine the erosion rates on the various land uses and the sediment yield from the watershed to the various streams and to Hilo Bay. The investigation involved inspection of portions of the watershed, reviewing local erosion and sediment study data, and talking to residents about the erosion and sediment problems in the area. Using this data, the average annual sediment yield for each of the land uses was estimated. The average annual sediment yield from the watershed is estimated at 43 acre feet.

The effect of the proposed land treatment on the sediment yield for the various land uses was evaluated using the method described in SCS, South Technical Service Center's EWP Technical Guide No. 15, "Guide to Estimating Effects of Land Treatment on Rates of Erosion." It is estimated that the installation and application of the proposed land treatment will result in a sediment reduction of 26 percent for the entire watershed.

Hydrology

Basic Data: There are no streamflow data available at the proposed diversion sites except for two indirect measurements. Four crest stage gages were installed in February 1971.

One hourly and two daily rain gages are in operation in the project area. Records for one of the daily gages are published by the Hawaii Division of Water and Land Development, Department of Land and Natural Resources. Records of the other gages are published by the U.S. National Weather Service.

Other data include streamflow records of the Wailuku River and Waiakea Stream located south of the project area. The gage in Wailuku River at Piihonua has given a continuous record since installation in 1929. Waiakea Stream, located slightly south of this watershed, was gaged immediately upstream of Komohana Road from June 1957 to June 1967. The rain gage now in operation on the drainage area of Waiakea Stream was installed at Camp 6 in 1953. Records of the stream gages are published by the U.S. Geological Survey. The rainfall records are published by the U.S. National Weather Service.

A report published by the U.S. Corps of Engineers, Honolulu, Hawaii, "Flood Plain Information Study, Kaumana-Punahoa, Hawaii, Hawaii," was also used for reference.

These stream and rain gage records, soil surveys, land use maps and data from field surveys of ground cover conditions were used in estimating the hydrologic characteristics of the watershed.

Peak Flow Rates; Present Watershed Conditions: Peak flow rates were computed using the principles described in Chapter 16 of the SCS National Engineering Handbook (NEH), Section 4, Hydrology. Much of the computation was done by computer using SCS Technical Release 20, "Computer Program for Project Formulation."

Rainfall amounts were taken from U.S. Weather Bureau Technical Paper No. 43, "Rainfall Atlas of the Hawaiian Islands."

Watershed characteristics used to develop volumes and peak rates of runoff include times of concentration (TC) and curve number (CN). Times of concentration were estimated using procedures described in Chapter 15, NEH-4. Curve numbers for the sugarcane and developed areas were estimated using procedures described in Chapter 9, NEH-4. The forest and pasture curve numbers were developed from analysis of rainfall-runoff data.

Rainfall-runoff analyses were made on the July 25, 1966 storm, which caused extensive damage to the watershed. Indirect measurements of peak flows were made by the USGS in Waipahoehoe Stream at Akolea Road and in Alenaio Stream at Kapiolani Street. Waipahoehoe Stream is a tributary of Alenaio Stream but separated by a long, broad, and gently sloping brushy area. The drainage area of Waipahoehoe Stream is mainly forest and pasture land. The Alenaio Stream drainage basin includes residential areas.

The analysis involved the use of rainfall records to estimate rainfall depth and distribution over the drainage area. A curve number was calculated and used to develop triangular unit hydrographs. These unit hydrographs were combined to make the composite hydrograph. This procedure is described in Chapter 16, NEH-4. The result of the analysis showed that CN 27 was representative for the forest and pasture lands for the drainage area above Waipahoehoe Stream.

An extensive analysis of the data on the adjacent Waiakea Stream also indicated the same general magnitude of CN for pasture and forest lands. Frequency analyses were made of the annual 24-hour rainfall and runoff records. However, in converting the runoff from million gallons per day to inches, only the area estimated to contribute to flood flows was used. The effective area was estimated to extend to elevation 2,500 feet where the drainageways became undefined and discontinued. Rainfall-runoff values at corresponding frequencies were plotted on CN curves and a band between CN 25 and 30 was indicated. CN 27 was used to reconstruct the two highest storm hydrographs on record. The reconstructed hydrographs approximated the shape of the natural hydrographs with the computed peak flows about equal to the actual peak flows.

The CN used to compute the estimated peak flow in Alenaio Stream at Kapiolani Street was a weighted CN for forest and pasture lands derived above and CN for residential and sugarcane taken from Chapter 9, NEH-4. The computed peak flow was 4,000 cfs while the measured peak was 2,800 cfs, a difference of 1,200 cfs. The computed peak was considered reasonable. The 1,200 cfs was believed lost in the lava field below Kaumana Drive where Waipahoehoe Stream becomes undefined. Investigations revealed that this lava field contains many depressions. Observations showed that Waipahoehoe Stream could be flowing to the lava field but Alenaio Stream remained dry. Alenaio Stream flowed only after a long and intense rainstorm.

Another means of gaging the reasonableness of the computed peak flows from the 1966 storm was to develop a discharge-frequency curve of Alenaio Stream at Kapiolani Street.

The discharge-frequency curve indicated that the 1966 storm would have a recurrence interval of about 10 years. Considering the number and magnitude of historical storms that have occurred in the Hilo area, the 1966 storm perhaps may have a slightly higher recurrence period.

Peak Flow Rates; Future Watershed Conditions: The CN used for design peak flow computations were adjusted for the projected change in land uses. A great change in their hydrologic characteristic is anticipated in the woodlands as they are converted into residential areas. The rough and broken surfaces will be leveled, reducing surface storage; areas covered with buildings and roads will become impervious; and areas left open for lawns and gardens will be covered with compacted soil, reducing the original high percolation rate. It is estimated that the CN will change from 27 to 85. Also, the peak flow reduction estimated in the order of 1,200 cfs by the lava field along the reach between Kaumana Drive and Komohana Road was assumed lost.

The times of concentration and travel were adjusted for projected land use changes and stream reach improvements. Overland flow velocities on brushy areas were modified to paved street velocities. Travel times on poorly defined channels were changed to travel times on improved channels.

The computed peak flows compared favorably with those contained in the previously mentioned U.S. Corps of Engineers' "Flood Plain Information Study." Plate A-7 of that report indicated that the peak flows with 8.7 square miles of drainage for the 100-year flood was 8,200 cfs and the standard project flood was about 13,500 cfs. The SCS value in Alenaio Stream at Kilauea Avenue (D.A. = 8.71 sq. mi.) was 11,500 cfs, greater than the Corps' 100-year flood but less than their standard project flood.

Floodwater Depths: Floodwater depths used in the flood damage evaluation and flood plain delineation were estimated for the 1, 2, 4, and 20 percent chance storm events. Hydrologic data used was similar to that used in design flow computation. The drainage area will be near full development by the time the structural measures are installed. This resulted in slightly deeper water depths than needed for the study. However, due to the character of flooding in this area, the increase in flood depths was considered insignificant.

Flood plain limits along Alenaio Stream downstream of Kapiolani Street were estimated using the water surface computer program (FW-HD1-1130F). This was supplemented by manual computation where the floodwaters were diverted by inadequate culverts onto streets and other open areas between buildings and through residential and commercial areas of downtown Hilo. Results compared favorably with depths reported for the 1966 storm.

Floodwater depths in the Ainako and Chong Street areas, where damages are caused by overland flooding, were estimated in the field based on depths and extent of damages from the 1966 storm. The character of flooding in these areas defies existing computational methods of flood routing. Lot topography, location of houses on lots, and flow barriers such as rock walls, shrubs, and trees were all considered in estimating the various floodwater depths.

Economics

The existing trends of agricultural operations and urban development were analyzed in terms of their probable economic impact on the future economy of the watershed. Watershed land use and state policy for preserving cropland was analyzed to determine the effects of the project on future land use patterns and damages. The forming of a sugar cooperative and a long-term lease were also taken into consideration. The sugar cooperative will reduce cost of processing which will help sustain sugar production. The long-term lease guarantees that cropland will remain in sugar production.

Floodwater damage estimates were based on field schedule information obtained from land owners and operators in the Wailuku-Alenaio watershed. Damage information was gathered on the 1948, 1966, and 1969 storms. Post-flood damage surveys were conducted by SCS for the 1966 and 1969 storms and were analyzed to evaluate past damages under existing conditions.

Damages were classified according to types, i.e., sediment, erosion, and floodwater. Data was further categorized into residential, commercial, agricultural, and public property. Public property includes damages to public roads, bridges, utilities, and emergency operations. This provided a basis for the evaluation.

Damage appraisal in agricultural areas was based on losses to crops and property, including private roads. Crop damage was determined from actual crop losses and estimated losses in net income for major crops affected. Historical data was brought up to a common base year for the damage evaluation.

A combination of the overland flow and stage damage methods was used in the analysis of floodwater damage reduction benefits. An evaluation was made on damages that would occur from a flood which could be expected on an average of once in 100 years. "Floodwater Damage Estimates on Residential and Commercial Property," released as SCS's TSC Technical Note Watershed PO-4, dated June 1971, was used as a basis for the residential damage estimates. Field checks and comparison with flood surveys were made to assure similarity of local conditions with the technical note. Damages were correlated with depths of flooding for each event used in the frequency analysis.

Floodwater damages were calculated "without project" conditions and "with project" conditions. Damages were reduced to average annual damage by using damage frequency curves as discussed in SCS's Economics Guide. The difference between "without project" and "with project" average annual damages constitutes the reduction of damages. Benefits from reduction of damages were estimated from the effect of reduced flood depths and areas.

The future increase in flood plain damages was based on the projected increase in per capita personal income, since future flood damage to urban properties will increase at about the same rate as projected personal income. The estimated increase in residential damages within the Hawaii resource planning area is based on personal income projected by OBERS.

Damage reduction resulting from installation of land treatment measures was calculated as a percent of the total damage reduction. A study of routings, with land treatment improvements only, was used to arrive at the percent factor.

Indirect damages are caused by disruption of travel to markets, extra travel time, delays in marketing, and extra expenses. Based on this data and information previously analyzed for watersheds, it was determined that 10 percent for agricultural, 15 percent for residential, and 20 percent for public utilities of the respective direct damages would be an equitable amount for indirect damages.

Project installation will provide opportunities for employment of presently unemployed or underemployed residents. Data from similar projects indicates that local labor costs will be approximately 20 percent of the construction costs. This value for the structural measures was amortized and converted to a redevelopment benefit. The value of local labor employed in project operation and maintenance was treated as a decreasing annuity for 20 years and converted to an average value for the project life. It was also used as a redevelopment benefit.

Secondary benefits, stemming from the increased production of goods and services created by the project, will be realized by workers, processors, and business establishments in the trade area. The evaluation of these benefits was limited to those which would occur locally as a result of project installation. These benefits were estimated to equal 10 percent of the primary benefits, with the exception of those resulting from a reduction of indirect damage, plus 10 percent of the project operation and maintenance cost.

Urban damage estimates were adjusted to current prices by using U.S. Department of Commerce Construction Costs Composite Index (1967 = 100) wherever applicable.

Details of the procedures used in the investigation are described in the SCS's "Economics Guide for Watershed Protection and Flood Prevention."

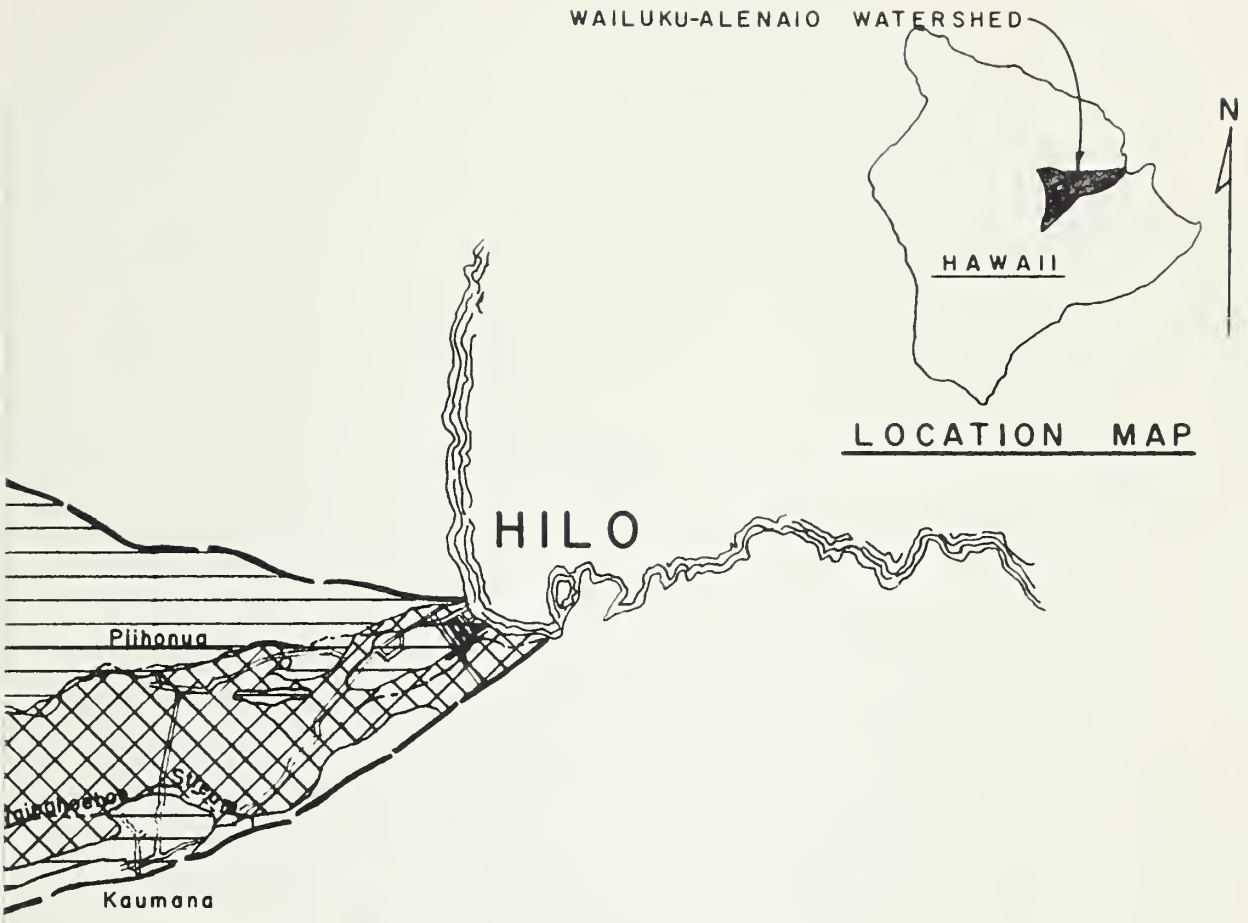


FIGURE 1

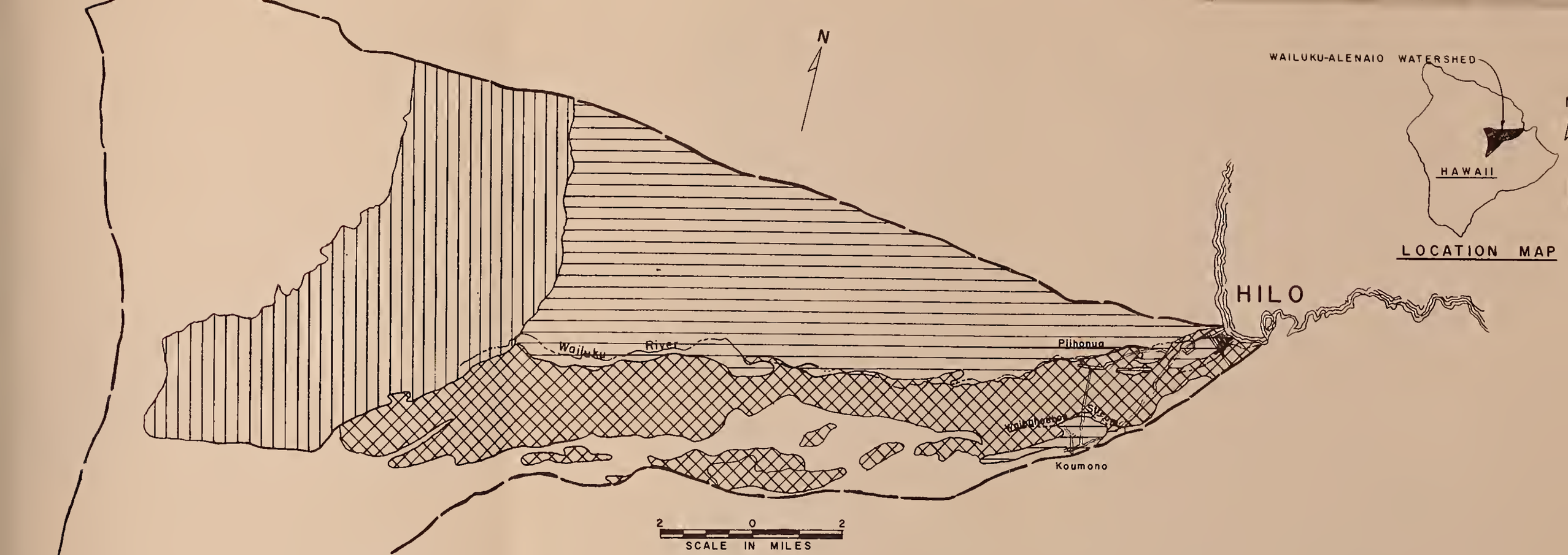
SOIL ASSOCIATION MAP

WAILUKU—ALENAIO WATERSHED

U. S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

SEPTEMBER 1975



LEGEND

Akoko-Honokoo-Koiwiki Association: Deep, gently sloping to steep, moderately well and well-drained soils that have a moderately fine textured subsoil; on uplands.

Kekoke-Keei-Kiloo Association: Very shallow, gently sloping to steep, well-drained organic soils over pohoehoe or fragmented aa lava; on uplands.

Honipoe-Moile-Puu Oo Association: Deep, gently sloping to steep, well-drained soils that have a medium textured to moderately fine-textured subsoil; on uplands.

Lava Flows Association: Gently sloping to steep excessively drained, nearly level, barren lava flows and sandy and cindery soils; on uplands.

FIGURE 1
SOIL ASSOCIATION MAP
WAILUKU-ALENAIO WATERSHED
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
SEPTEMBER 1975

FIGURE 2

EXISTING LAND USE

WAILUKU-ALENAIO WATERSHED

U. S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

SEPTEMBER 1975

MAUNA KEA

FR

G

WG

P

G

G

Wailuku River

FR-W

S

Plihonua

U

Ainako

W

P

Waipahoehoe Stream

S

S

U

Kaumana

HILO

Hilo Bay

N

WAILUKU-ALENAIO WATERSHED

HAWAII

N

LOCATION MAP

2 0 2

SCALE IN MILES

FR

MAUNA LOA

LEGEND

S	Sugar Cane
P	Improved Pasture
G	Grassland
FR-W	Forest Reserve (Closed Watershed)
FR	Forest Reserve (General Use or Game Mgt. Area)
W	Outside Reserve (Not Grazed)
WG	Outside Reserve (Grazed)
U	Urban

FIGURE 2

EXISTING LAND USE

WAILUKU-ALENAIO WATERSHED

U. S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

SEPTEMBER 1975

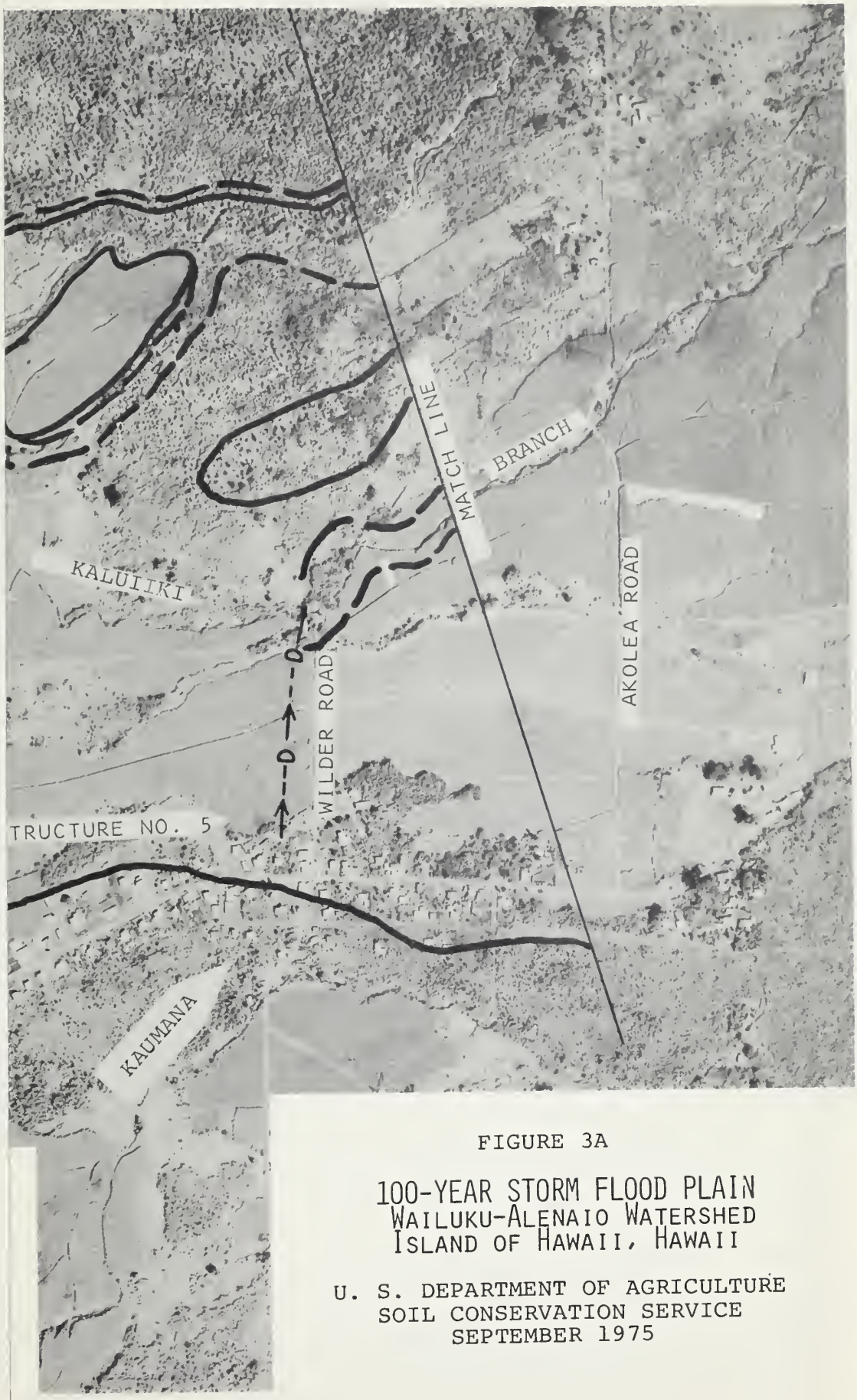


FIGURE 3A

100-YEAR STORM FLOOD PLAIN
WAILUKU-ALENAIO WATERSHED
ISLAND OF HAWAII, HAWAII

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
SEPTEMBER 1975

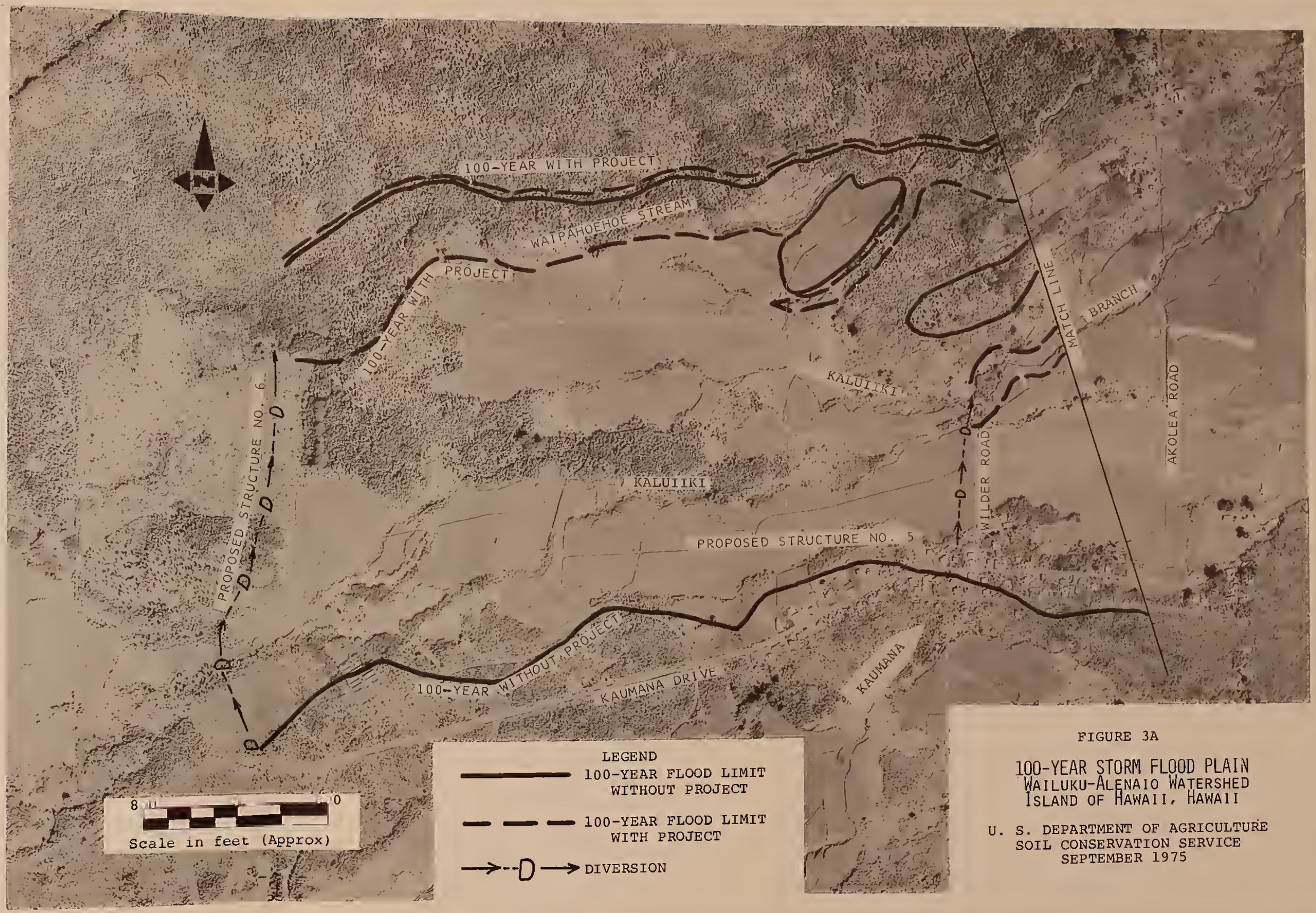


FIGURE 3A

100-YEAR STORM FLOOD PLAIN
WAILUKU-ALENAIO WATERSHED
ISLAND OF HAWAII, HAWAII

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
SEPTEMBER 1975

OOD LIMIT
PROJECT

OOD LIMIT
JECT

RK

NRY WALL

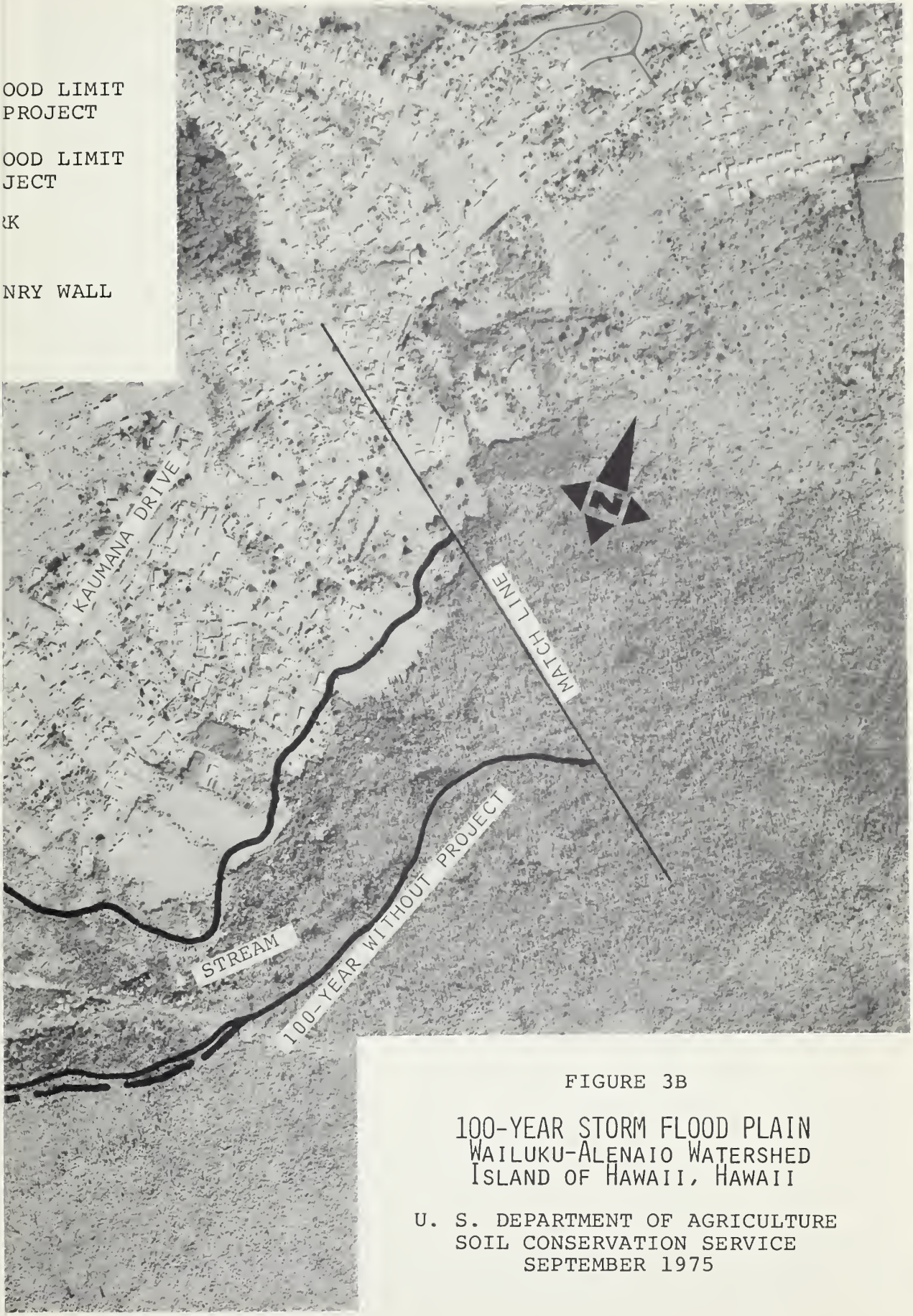


FIGURE 3B

100-YEAR STORM FLOOD PLAIN
WAILUKU-ALENAIO WATERSHED
ISLAND OF HAWAII, HAWAII

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SOIL CONSERVATION SERVICE
SEPTEMBER 1975

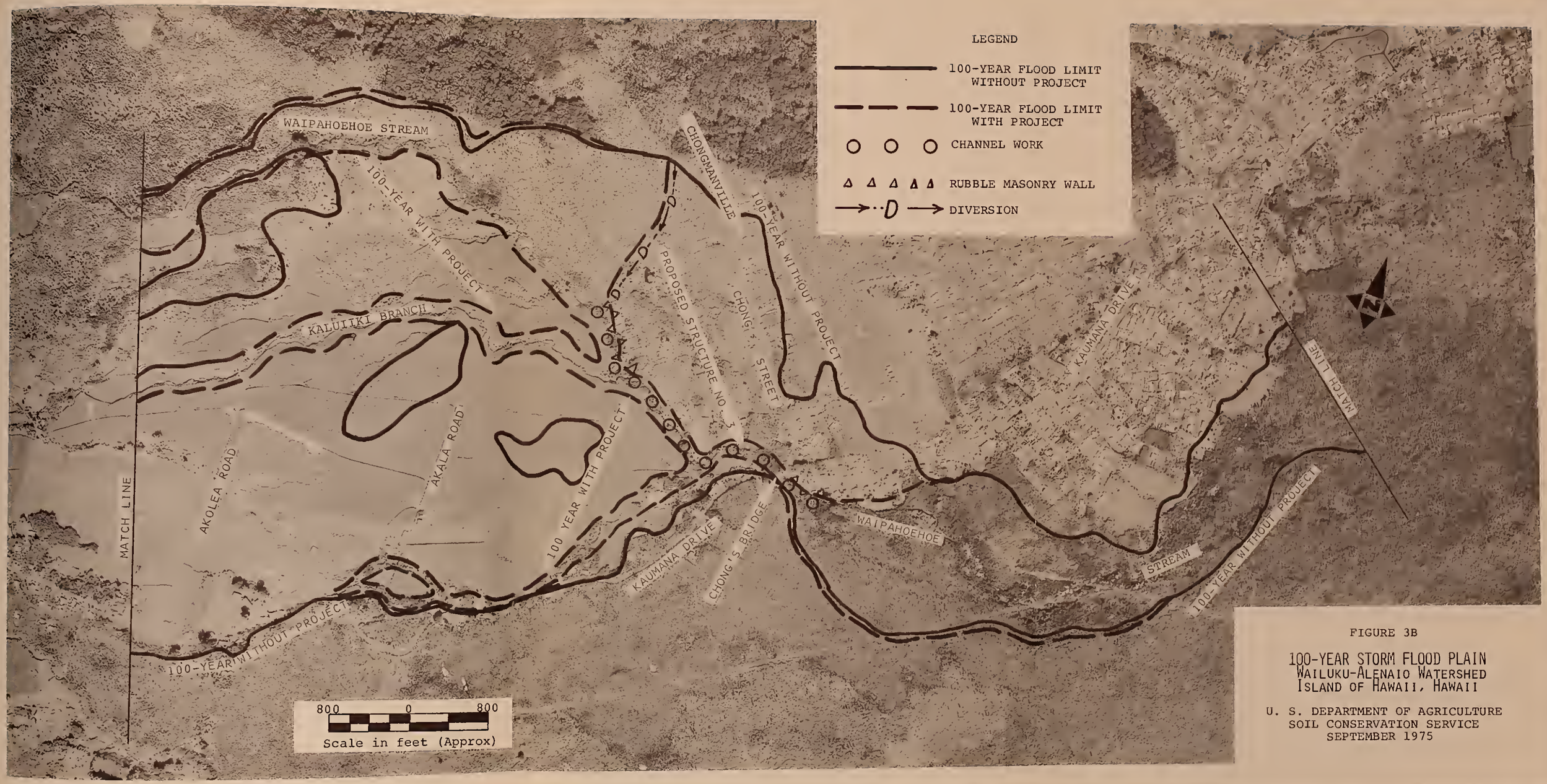

FIGURE 3B

100-YEAR STORM FLOOD PLAIN
WAILUKU-ALENAIO WATERSHED
ISLAND OF HAWAII, HAWAII

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SOIL CONSERVATION SERVICE
SEPTEMBER 1975

FIGURE 3C

100-YEAR STORM FLOOD PLAIN
WAILUKU-ALENAIO WATERSHED
ISLAND OF HAWAII, HAWAII

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SOIL CONSERVATION SERVICE
SEPTEMBER 1975

FIGURE 3C

100-YEAR STORM FLOOD PLAIN
WAILUKU-ALENAIO WATERSHED
ISLAND OF HAWAII, HAWAII

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FIGURE 3D

100-YEAR STORM FLOOD PLAIN
WAILUKU-ALENAIO WATERSHED
ISLAND OF HAWAII, HAWAII

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FIGURE 3D

100-YEAR STORM FLOOD PLAIN
WAILUKU-ALENAIO WATERSHED
ISLAND OF HAWAII, HAWAII

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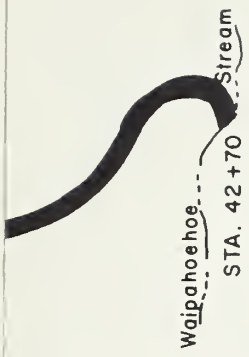
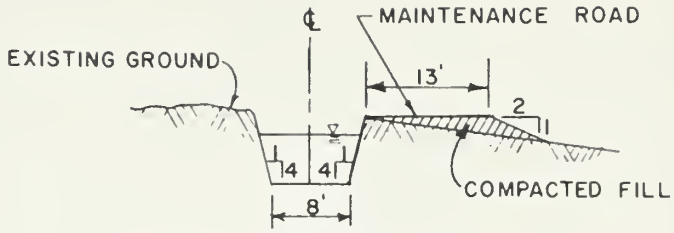
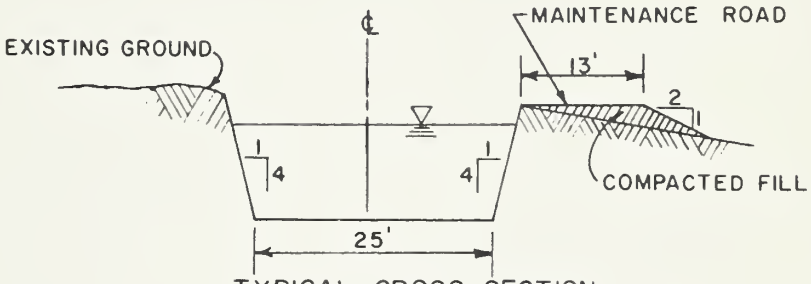
SEPTEMBER 1975





TYPICAL CROSS SECTION
Sta. 2+50 to Sta. 12+50
(Not to Scale)



TYPICAL CROSS SECTION
Sta. 12+50 to Sta. 42+70
(Not to Scale)

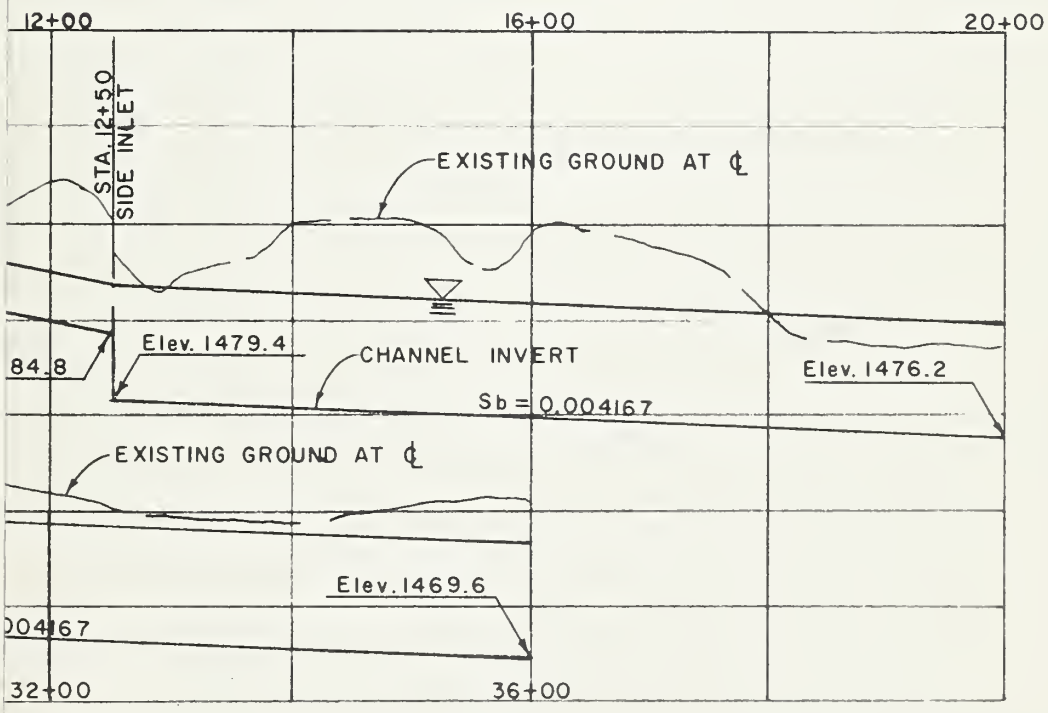


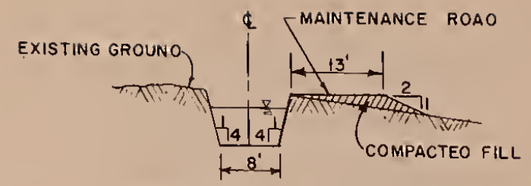
FIGURE 4
STRUCTURE NO. 6
WAILUKU-ALENAIO WATERSHED
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
SEPTEMBER 1975

PLAN

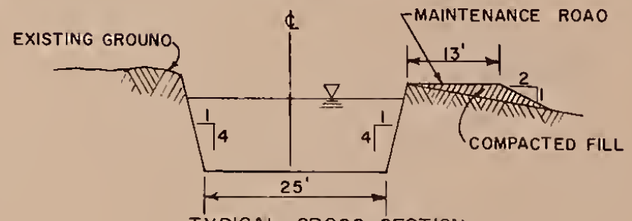
400 200 0 400
SCALE IN FEET

LEGEND

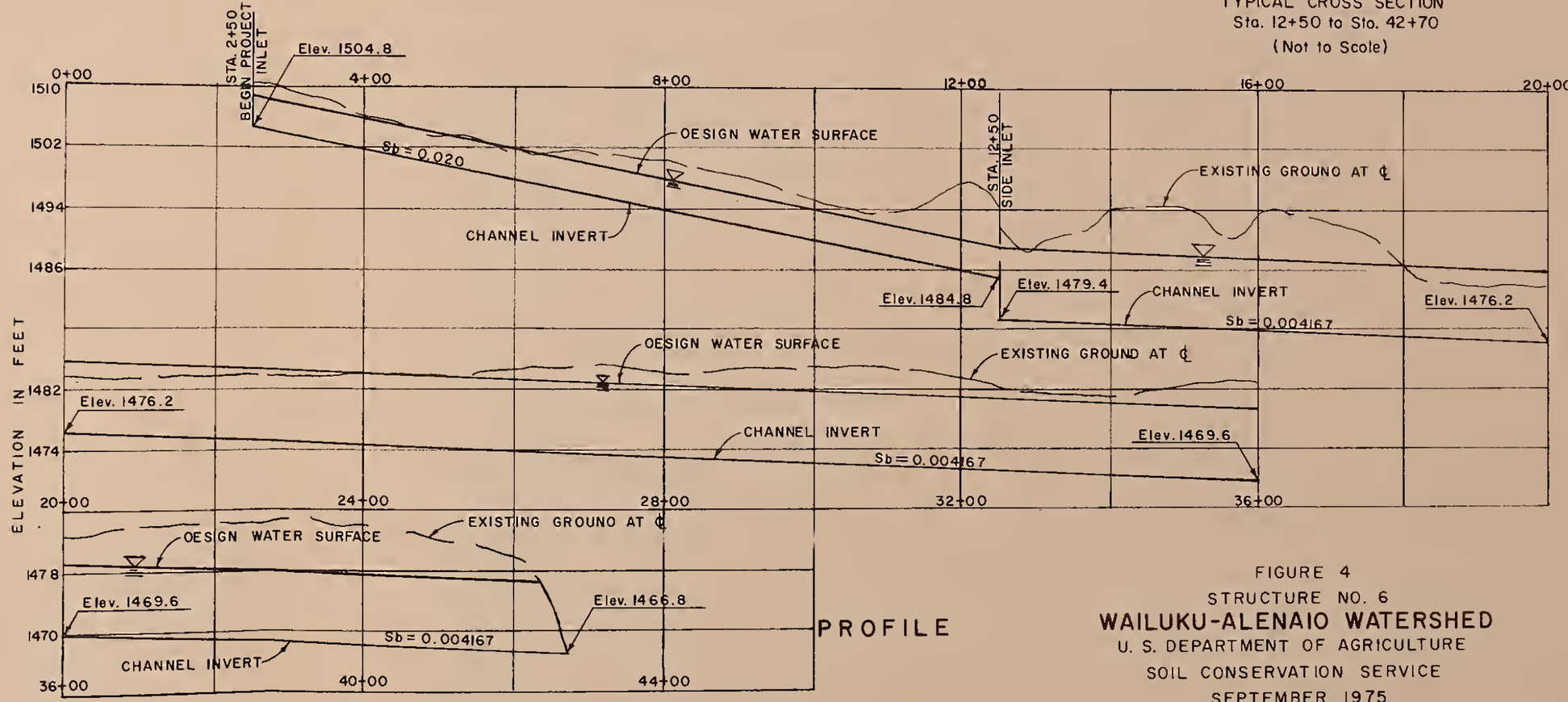
Existing Stream
Floodwater Diversion
Paved Road



TYPICAL CROSS SECTION
Sta. 2+50 to Sta. 12+50
(Not to Scale)

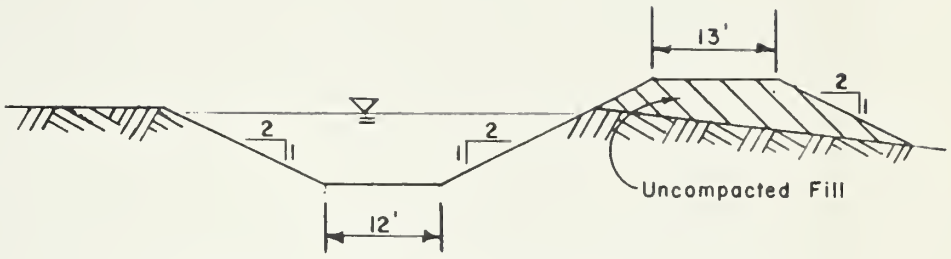


TYPICAL CROSS SECTION
Sta. 12+50 to Sta. 42+70
(Not to Scale)



PROFILE

FIGURE 4
STRUCTURE NO. 6
WAILUKU-ALENAIO WATERSHED
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
SEPTEMBER 1975



TYPICAL CROSS SECTION
(Not to Scale)

LEGEND

Existing Stream
Floodwater Diversion
Paved Road

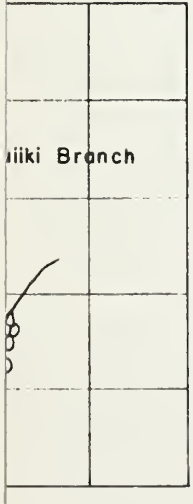
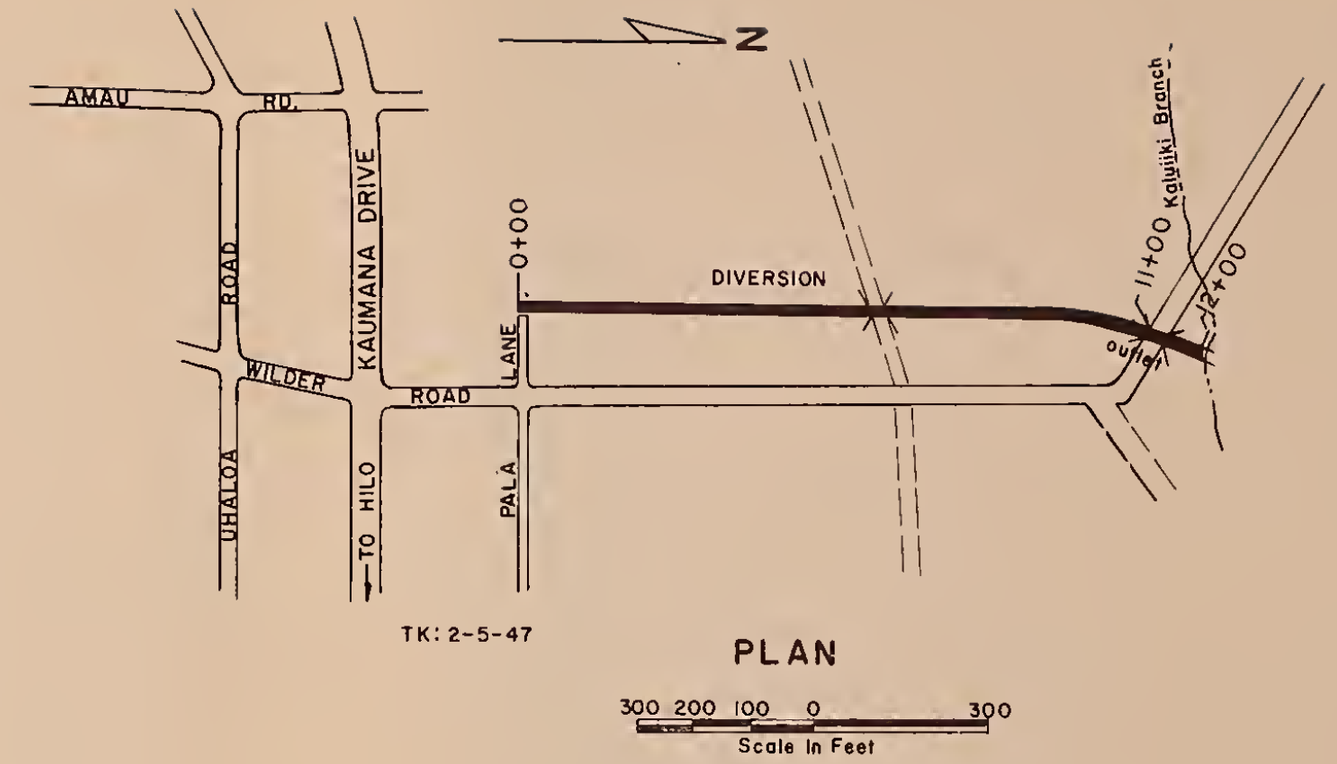


FIGURE 5
STRUCTURE NO. 5
WAILUKU-ALENAIO WATERSHED
ISLAND OF HAWAII, HAWAII
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
SEPTEMBER 1975

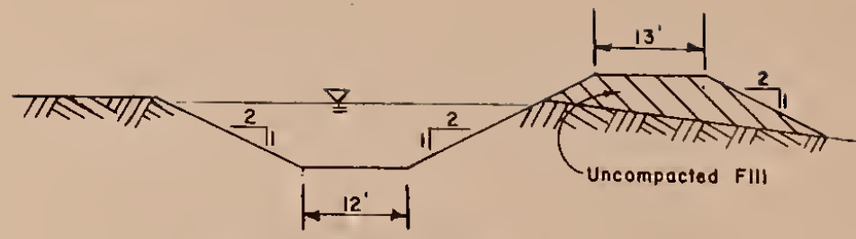


TK: 2-5-47

PLAN

300 200 100 0 300

Scale In Feet



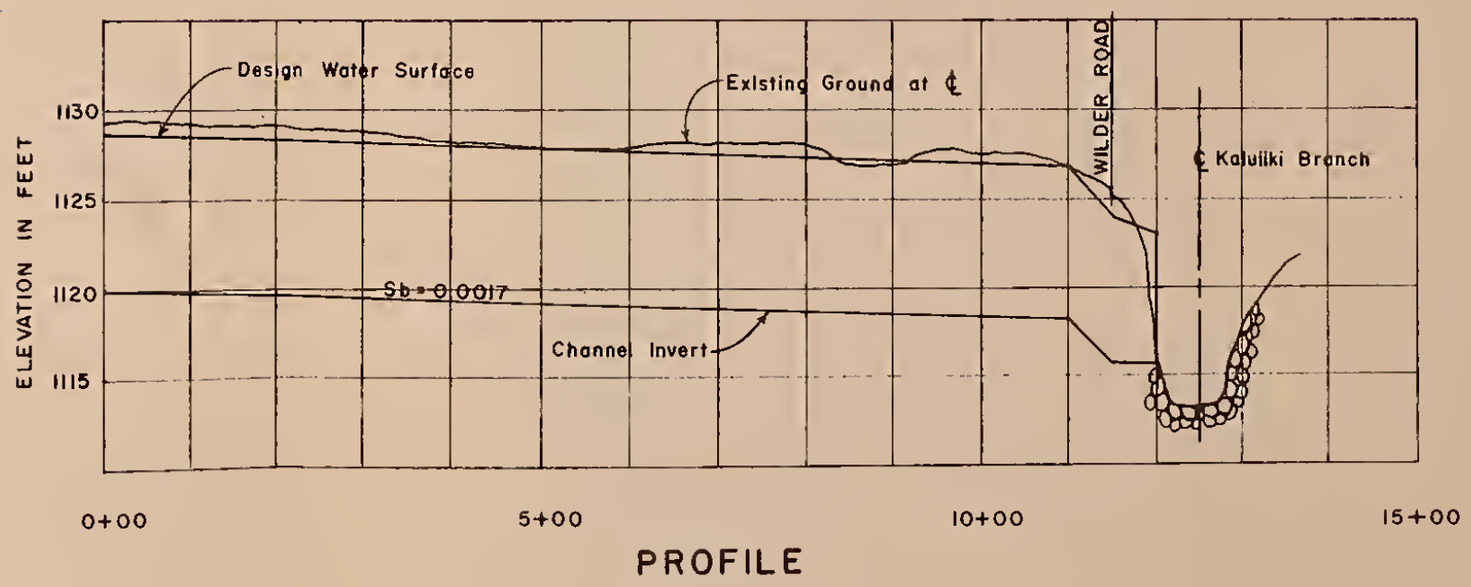
TYPICAL CROSS SECTION
(Not to Scale)

LEGEND

Existing Stream

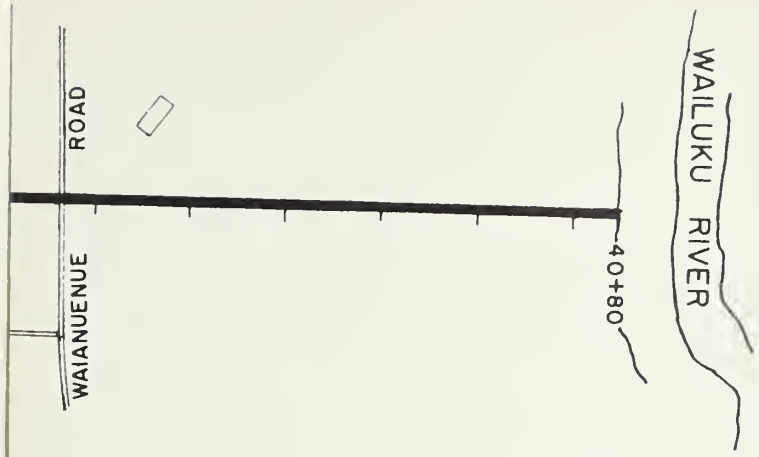
Floodwater Diversion

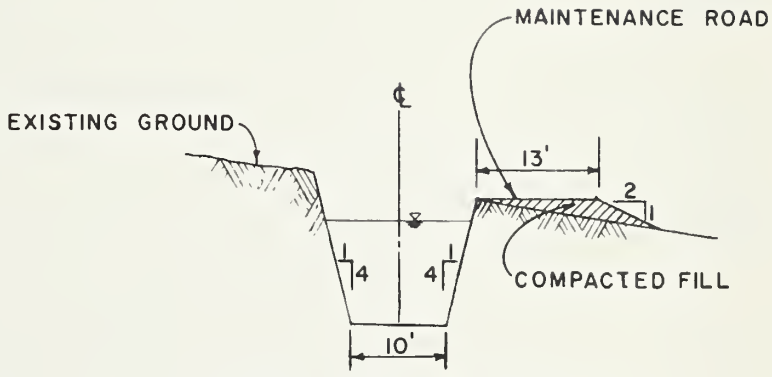
Poved Raod



PROFILE

FIGURE 5
STRUCTURE NO. 5
WAILUKU-ALENAIO WATERSHED
ISLAND OF HAWAII, HAWAII
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
SEPTEMBER 1975





TYPICAL CROSS SECTION
(Not to Scale)

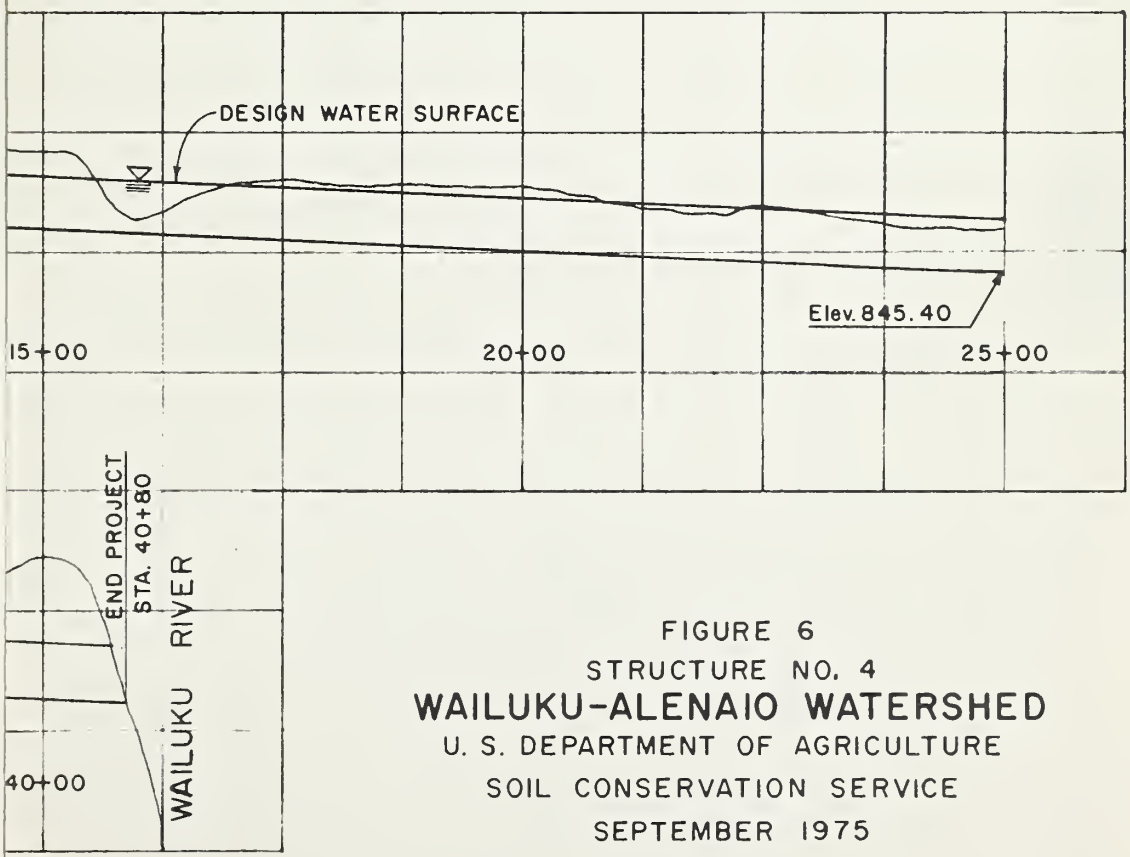
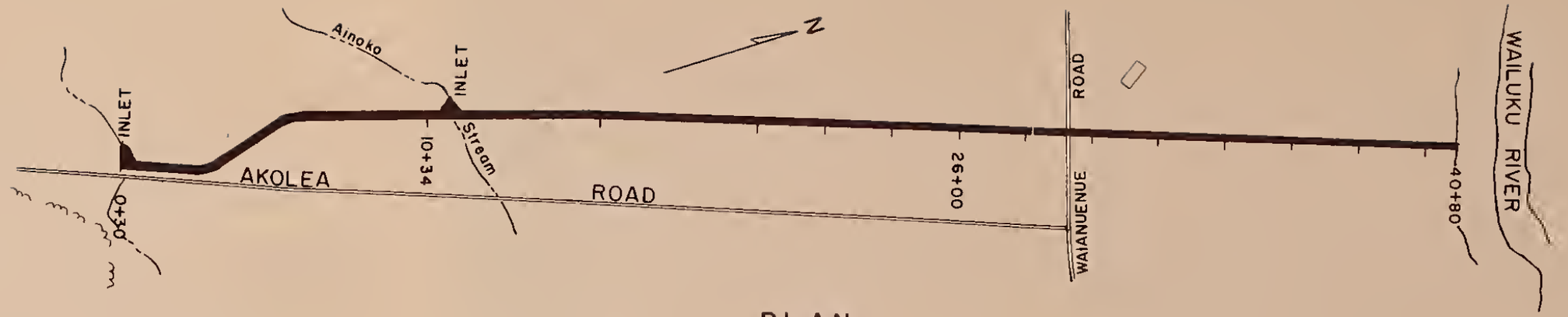


FIGURE 6
STRUCTURE NO. 4
WAILUKU-ALENAIO WATERSHED
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
SEPTEMBER 1975

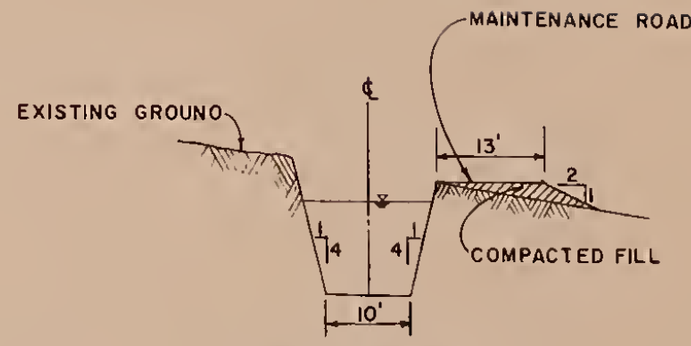


PLAN

400 200 0 400
SCALE IN FEET

LEGEND

Existing Stream
Floodwater Diversion
Poved Raad



TYPICAL CROSS SECTION
(Not to Scale)

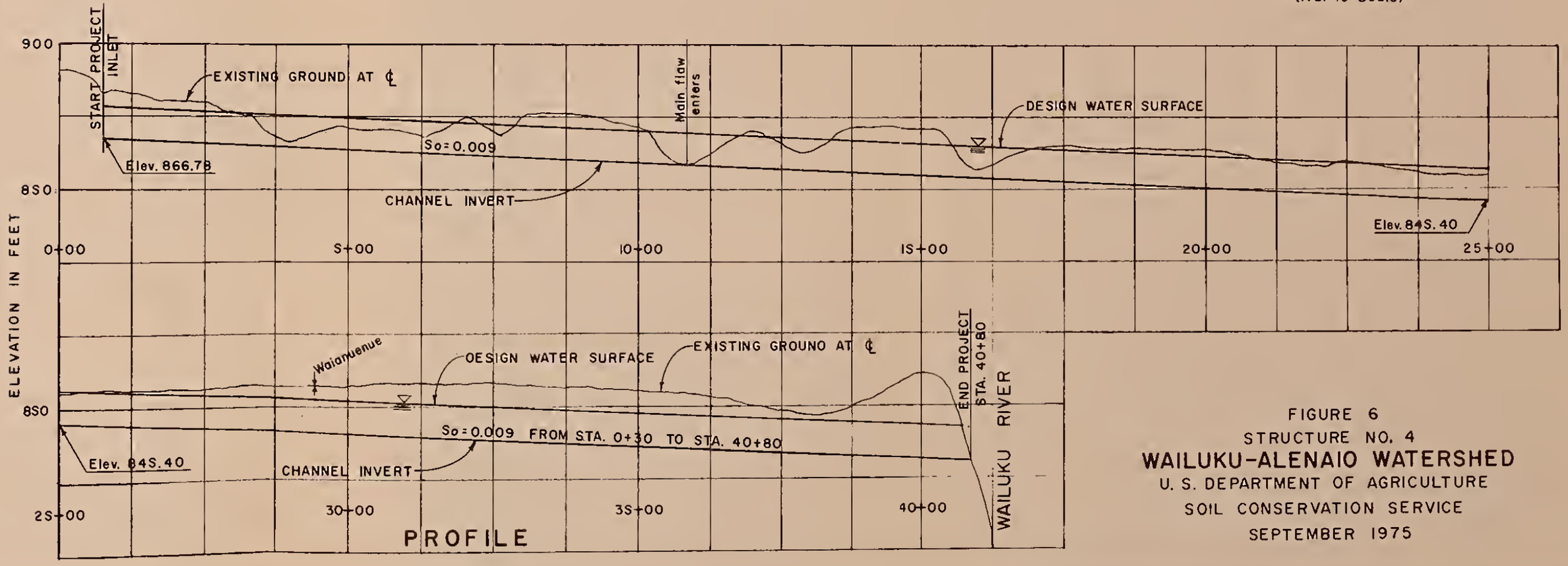


FIGURE 6
STRUCTURE NO. 4
WAILUKU-ALENAIO WATERSHED
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
SEPTEMBER 1975

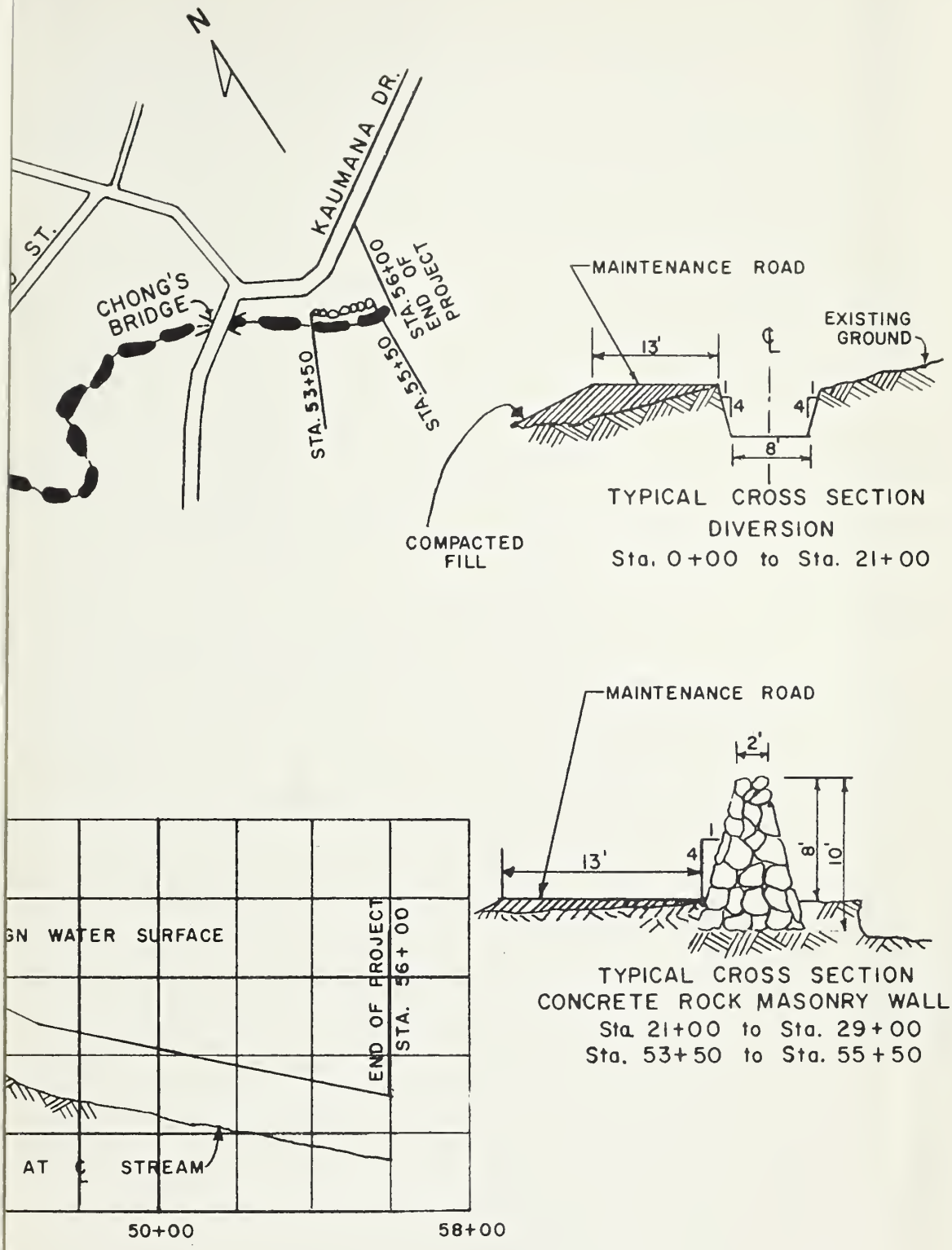


FIGURE 7
STRUCTURE NO. 3
WAILUKU-ALENAIO WATERSHED
ISLAND OF HAWAII, HAWAII
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
SEPTEMBER 1975

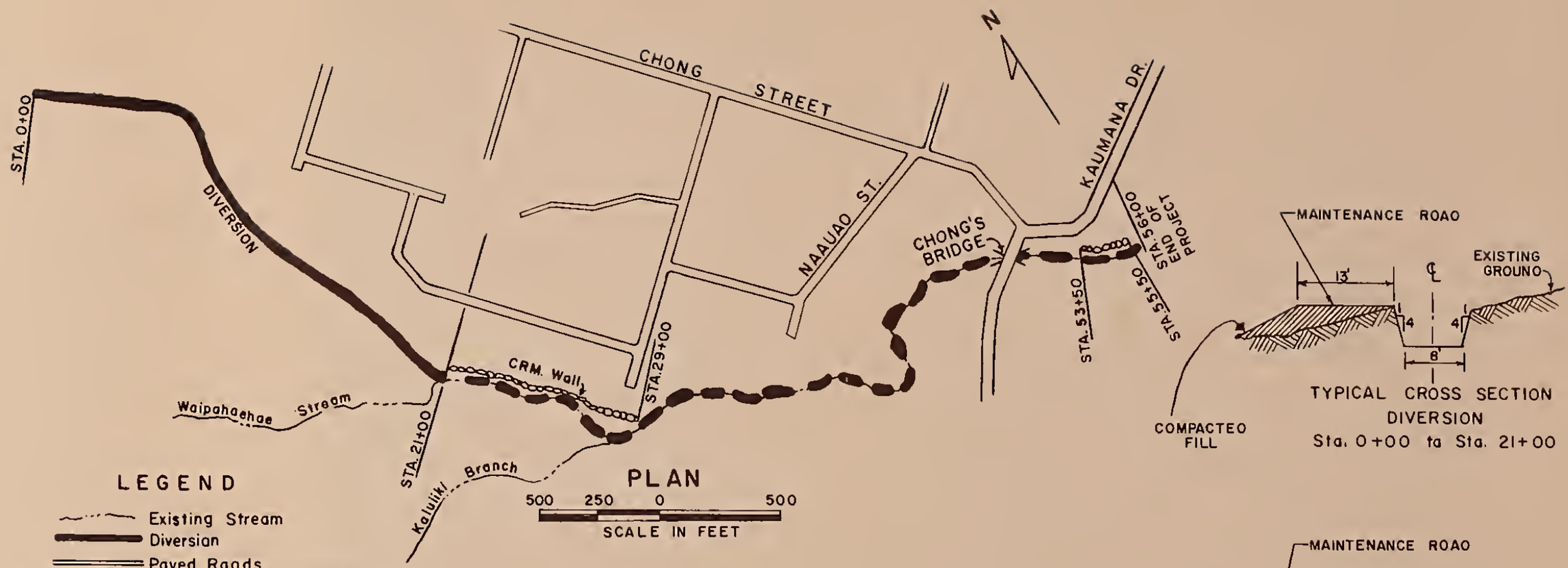
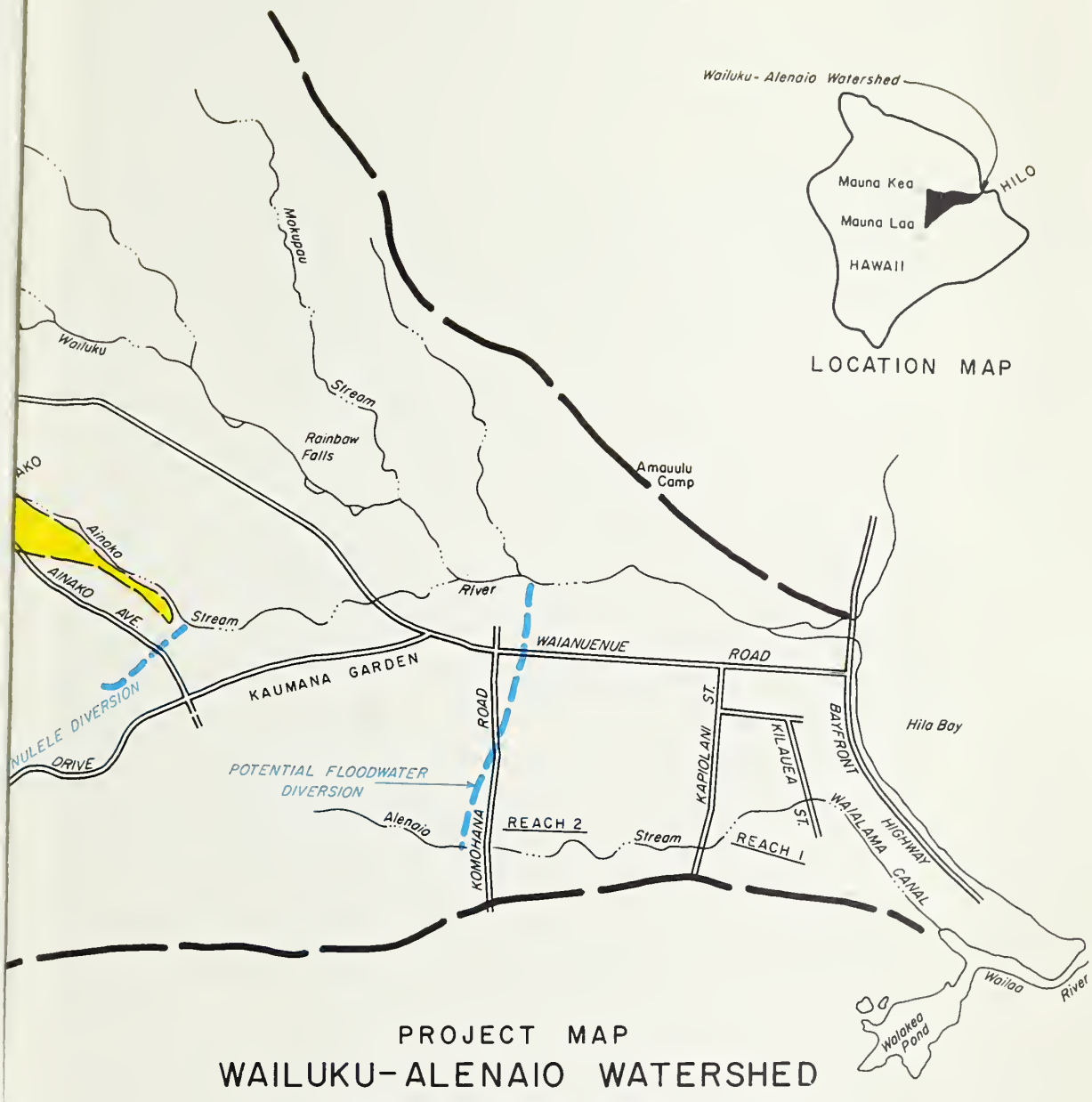


FIGURE 7
STRUCTURE NO. 3
WAILUKU-ALENAIO WATERSHED
ISLAND OF HAWAII, HAWAII
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
SEPTEMBER 1975



PROJECT MAP
WAILUKU-ALENAIO WATERSHED

ISLAND OF HAWAII, HAWAII

U.S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

SEPTEMBER 1975

PROJECT MAP

WAILUKU-ALENAIO WATERSHED

ISLAND OF HAWAII, HAWAII

U.S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

SEPTEMBER 1975

SCS-PORTLAND OR 1976

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